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The Preservation of Pavements.

One of the most important pieces of news printed in this journal in a long time was the announcement made last week that the mayor of New York had appointed a committee to investigate the causes of the frequent obstructions and upheavals of the pavements of that city and to report on a plan for minimizing them. Perhaps the fact that The Engineering Record has its main offices in New York leads it to think that pavements receive less real care in that city than elsewhere, although the attention they get anywhere is little enough, but its opinion has long been that the treatment a pavement received after it was once laid in the Borough of Manhattan was characterized by the most frank disregard not only of sound engineering principles, which are likely to be considered as a nuisance, but also by an absence of any appreciation of the fact that the pavements so blithely dismembered cost a lot of money. For example, a wood pavement was laid in front of the offices of this journal over a year ago, and since that time workmen have been diligently tearing it to pieces for various reasons. The result is a succession of uneven areas which will cause the surface to wear out long before it would had it been disturbed less often and been repaired properly after being disturbed. It is to be expected that pavements must be torn up occasionally, but there is no excuse for making this a sort of continuous performance or for permitting the work to be done in any but the most careful manner.

One reason for the wretched condition of affairs in New York is that so many different departments of the city government have more or less to say about the streets. After reading the long list of them given in the mayor's announcement printed last week it seems a little strange to notice the omission of the coroner from that list, for surely if there is anything done to death and deserving an official post mortem examination it is the average pavement in the lower part of New York that has been laid a year. It is true that in order to get permission from a city department to do any work within its province is oftentimes a tedious task, but that is no reason for giving other departments the right to order or permit the obstruction or tearing up of streets. It is altogether too easy to secure from some source the permission to do such work, for if the permission were not so readily obtained there would be more pains taken to design and construct underground works in such a manner that these eruptions on the face of the streets would be far less frequently seen. As it is now, any intimation that something is wrong with steam, gas or water pipes immediately sets a gang of men throwing up dirt in the middle of a crowded street with as little regard to their surroundings as is shown by a terrier pup digging at a rat hole.

One great difficulty about the regulation of street obstruction and opening is that the nature of the underground works that will be necessary in the future cannot be foreseen except in a very general way, and it is not good business to load down the present generation with the cost of extra large works which will be fully enjoyed only by the next generation. It is not possible to foretell just what new water mains and gas pipes will be needed in a city street, nor to say when a sewer must be rebuilt. The various conduits of public service corporations must also be provided for. Of course the ideal time for putting all these underground works in good condition is when a pavement is being replaced. Unfortunately the water department or the sewer department may not have any money available for the purpose at the time, while the private companies may not see any advantage in doing work which can be just as well put off for a few years. This financial consideration of the subject is one that is often overlooked except by those engaged in municipal work, and if the mayor's commission can devise any plan by which the construction of a new pavement in a street must also be accompanied by the repairs of all works below that pavement at the same time it will earn the hearty thanks of the community.

The city is fortunate in having as its mayor a man who studied engineering somewhat before he descended into the pitfalls of the law, and it is not surprising, therefore, that he was able to place his finger on the weak point of the present system of street control, the number of departments which have something to say about it. It is not possible to suggest definitely any remedy without more complete information than this journal possesses at present. It is apparently certain, however, that the only way to get relief that will amount to anything is to place complete control of street openings in the hands of a single bureau, which will issue permits for such work to other municipal departments, and to the private corporations upon deposit of a sum sufficient to pay for the repair of the pavement in proper manner. It is out of the question to allow permanent repairs to be made except by competent men doing no other kind of work. The parties, public or private, tearing up a street should be required to replace the surface in passable condition, and as soon as practicable afterward the regular repair gangs of the bureau in charge of street openings should make the permanent repairs. If no permit is granted until a sum is deposited ample to make these repairs, there will probably be a smaller number of upheavals of new pavements, and their effect will be less disastrous. Such a course will naturally make the work of repairing underground structures somewhat more expensive to those doing the work than it is at present. On the other hand it will keep the pavements in better condition and thereby save the taxpayers a much larger sum, and for this reason is sound public policy.

The Fuel Supply.

An official of the Geological Survey was recently quoted in an interview as stating that the coal supply in this country would suffice for 4,000 or 5,000 years. This is important, if true, and it would be exceedingly interesting to know the sources on which the geological gentleman proposes to rely. The present demand is in round numbers 300,000,000 tons per year, and is very rapidly rising. It is reckoned that up to the present time the supply has been reduced by about 6,000,000,000 tons. Now it may well be that there are considerable stores of coal still undiscovered in this country, and that the nominal supply in sight may be very large, but it is a fact that in some districts, and very important ones, it has already been necessary to resort to deep and rather expensive mining, and that in very large districts, too, the coal, while nominally very plentiful, is of very poor quality, varying from the meanest lignite up. How much of the minimum of 24,000,000,000,000 tons on which the geologist counted is of fairly good steaming quality and lies near enough the surface to be produced at anything approximating the present price? The amount named is, to put it mildly, somewhat largish; it would, if taken out and piled on the surface, cover the whole territory of the United States nearly a foot deep, and the present location of so large an amount or anything near it is not quite obvious. We should really like some of the specifications and the data on which they are based.

Of course most of the coal available now is fortunately near the surface and consequently easily mined, but this nearer portion will be at the present rate rapidly depleted. The anthracite has come to the point where the end must be reckoned with at no distant date. There is good reason to believe that men now living will see it relegated to the place now held by cannel coal, a luxury somewhat affected by old people who insist on following the habits of their earlier lives. Of bituminous coal of one sort or another there is much, but what will be the effect when it is obtainable only in very poor quality or at a greatly enhanced price? What would be the result of steam coal at double the present figure, which is within the easy bound of possibility not in a thousand years from now, but within a generation or two? We hope the prediction of the geological gentleman is correct, but it is none the less important to make every effort to conserve the fuel supply lest we reach rather rapidly a point at which the increasing price becomes a serious burden on industry.

It is worth noting that the consumption of coal per horse-power has diminished by something like a half in the last generation. Will the next generation be able to make enough further reduction to hold the coal consumption anywhere nearly constant? At present there seems little chance of any sweeping change, although practice is steadily improving. There is much hope in the generation of power in large plants at supplies of poor coal and in the utilization of water powers. The former scheme has often been considered, but never tried in this country, the latter is so far only a drop in the bucket, not enough to reduce the rate of increase of coal consumption perceptibly. Coal at double the current price would be a serious matter indeed, and the price is steadily on the up grade. It is very interesting to note the effect of this is even now being felt in the gradual movement of industry to the cheap coal fields of the South. Long before there is any real scarcity of coal this impulse will shift the scene of industrial development toward the fuel fields. It is a force that certainly will make itself felt in the distribution of population ere long. Such movements are like the movements of glaciers, slow and irresistible. Whether the last bit of coal is locked in a museum cabinet 4,000 or 5,000 years from now is a matter of only academic interest. The diminution of the cheap supply will make itself felt in decades not millenniums.

Rainfall and Run-Off in Sewerage Districts.

The capacity of storm-water sewers must be designed wholly in view of the run-off of their basins and the importance of accurate processes of estimation of that run-off has been fully recognized from the earliest days of rational sewerage planning. There have been few if any periods during the last sixty years when the determination of the run-off of drainage districts has not had the careful study of prominent members of the engineering profession. In this country the names of Adams, McMath, Kuichling, Hering and others have been associated with distinct and valuable contributions to the general subject, but there is much yet to be desired in connection with it. Among the latest studies of this nature is a paper by Mr. Charles E. Gregory in the "Proceedings" of the American Society of Civil Engineers for November of this year. This constitutes a careful study of nearly all the available data upon the subject in connection with the prominent formulas and diagrams which have been proposed heretofore for the determination of the principal elements of the problem. The author quite properly criticises the old approximate run-off rule of about 50 per cent., more or less, of the rainfall, the safe maximum rate of which was taken to be one inch per hour. It is within the experience of almost every engineer who has had to do with such work that occasionally, and not at such very widely separated occasions, sewers designed to meet those conditions were surcharged or disrupted by sudden downpours, which, while obviously greater than the ordinary, yet were not always such large rainfalls as to give reasonable ground for expectation of destructive results. As is justly observed by the author of the paper, rainfall records have usually been fatally incomplete in reference to various details which are required for the intelligent and accurate discussion of all problems of run-off and the design of structures whose safety and efficiency are dependent upon a clear realization of the actual conditions under which they are to perform their functions.

There are certain elements of rainfall which even at the present time are not always sufficiently recognized, either as to their actual magnitude or as to their effects upon storm-water sewer design. It is seldom that a rain gauge is conveniently found precisely at the right point for observation of the comparatively small drainage areas of storm sewers. A necessary consequence of this condition is that records of rainfall must be taken by observation at stations too frequently located entirely beyond the limit of the drainage area and sometimes at too great distance to render the results even approximately accurate for the location under consideration. Rainfall is much like wind pressure or velocity in that it is constantly varying from moment to moment at any given point, and consequently the records at one point may be quite misleading when applied to another point even at a comparatively short distance. This consideration is all the more significant for the reason that the drainage areas of sewer districts are generally very small as compared with the drainage areas usually treated in connection with the run-off of streams.

It is rare to find rainfall records used in connection with storm-water sewer design which apply with reasonable accuracy to the sewer district under consideration. Under such circumstances there is no course open to the engineer except to take such records as may be available in the general vicinity. The consequence is the consideration of the elements of his problem based upon data which do not properly belong to it. It is true that in many cases the records of the rainfall available for him are not far wrong and this is a fortunate feature of the general subject. These conditions, however, do not conduce to the establishment of accurate formulas. Indeed, if all other elements were strictly accurate, this one of defective rainfall records would preclude the establishment of any exact run-off formula.

There are other elements of equally approximate character. Any formula or diagram which may be established for the purpose of deducing the amount of storm-water to be carried away by a given sewer must be dependent not only upon the rate of rainfall, but also, as has always been recognized, upon the amount and character of the watershed. An area which is pervious and allows water to percolate into it to any sensible extent will clearly shed less rain falling upon it than if it were impervious. Again, the amount of rain which such a pervious surface will take or absorb, i. e., hold back from the sewer, will depend much upon its condition. If a drought has existed prior to a heavy downpour of rain, the run-off from a pervious surface may be much less than if the flood has been preceded by a moderate rain which has partially filled the open spaces of the pervious area. On the other hand, the closely paved areas of cities may be considered entirely impervious, yet experience shows, as is otherwise clear, that no surface can possibly discharge all the rain that falls upon it. Every so-called impervious surface will absorb a little water and some surfaces of that class, like those of brick, may absorb considerable water, to say nothing of the small pondage of shallow depressions which hold back some of the water from immediate off-flow.

These considerations and others which might be cited account abundantly for the general inapplicability of proposed formulas for run-off, which is justly observed by Mr. Gregory. While these unsatisfactory features are found in present formulas, and although it is manifestly not only desirable, but imperative, to push investigations in the direction of establishing better formulas, if possible, by improving the old forms or establishing new ones, it is a matter of grave doubt whether the great uncertainty of many features of the case will for a long time to come if ever permit any general and accurate formulas for run-off to be established. Such formulas as already exist, like those of McMath, Burkli-Ziegler and others, give reasonably safe results when used with judgment and applied to conditions similar to those for which they were originally established. The author of the paper proposes a formula which fits well a number of conditions, but it is highly improbable that it or any other can be used profitably throughout a great range of conditions. The influences of rate of rainfall, inclination of drainage surface, quality of surface, especially where the drainage area is made up of portions of largely varying character, the shape of the sewer district and other elements are so unmeasurable that in many cases erratic results will be likely to follow anything like a uniform application. Mr. Gregory's studies constitute a valuable addition to this class of literature, and not the least valuable feature of the paper is the emphasis which it lays, perhaps not intentionally, on the imperative necessity of applying any run-off formula only under the guidance of well-trained judgment, so that the unmeasured and as yet unmeasurable elements of the problem may be suitably allowed for.

Samuel Spencer.

When the magnificent progress of the South Atlantic States during the last fifteen years is reviewed carefully, it is apparent that a considerable proportion of it must be attributed to the engineer whose sudden death on Thanksgiving morning shocked the entire country. Samuel Spencer had all the qualifications necessary to take a foremost place in the ranks of the builders of the New South, and he had the energy and perseverance to make those qualifications count. His family lived below the Mason and Dixon line from early colonial days. He left school when sixteen years of age to join the Confederate army, and served for two years, until the close of the war. Then he went back to school, first at the University of Georgia and later at the University of Virginia, graduating at the head of his class in each case. By birth, military record and education he was thus identified with the South before his career began.

His college courses had been along the lines of civil engineering, and he at once found work in the engineering department of the Memphis & Savannah R. R. Here he rose through the grades of rodman, instrument man and resident engineer to the position of principal assistant engineer. He recognized, however, that the great work to be done at that time in the railway field was in the operating, rather than the engineering, department, and so he voluntarily dropped down to a clerkship in the Long Branch office of the New Jersey Southern R. R. in order to obtain the knowledge of details which is essential to success. It was a courageous step for a young man, recently married, but he saw its necessity as a stepping stone to future advancement. Not long afterward he joined the Baltimore & Ohio R. R. at a salary of $60 a month. He lived in the second story of a station building at Rockville, but he considered the hard work, long hours and small wages part of the price he must pay for his practical education. John W. Garrett, then president of the Baltimore & Ohio R. R., was not long in discovering him, and from that time he rose rapidly.

This is not the place to trace the various steps of his career, except so far as they point to his fitness for the post he held at the time of his death. When he left the Baltimore & Ohio R. R. in 1877 it was to become superintendent of transportation of the Virginia Midland R. R., a position he did not hold very long, but was valuable as revealing transportation conditions there. For many years after that, his work lay farther north and finally resulted in 1889 in his becoming the railroad expert of J. P. Morgan & Co. Even in those days that firm was eminent for its ability to reorganize companies which were in an unstable condition, and after four years' work in rehabilitating an Illinois road, Mr. Spencer was sent South as the receiver of the Richmond & Danville R. R. Co. and the East Tennessee, Virginia & Georgia R. R. Co. In about a year he had found out what the properties were good for, and, with his associates, organized the Southern Ry. Co., of which he was the president from its first meeting until his death.

What Mr. Spencer did for the Southern Ry. can be shown by a few figures. In 1894, it had 4,391 miles of track while to-day it has 7,515 miles, it had 623 locomotives and 19,694 cars then against 1,429 locomotives and 42,110 cars now, and it earned $16,643,298 then as compared with $53,641,438 last year. In 1894 it employed 16,718 men while on June 30 of this year it had 37,003 employes and a pay roll of $121,198,000. It is so well known, however, that he was a great railway expert that these things may be passed by without further comment. What Mr. Spencer did for the South deserves more notice, particularly as his work has not been appreciated as it should and has even been attacked by one of the muck-rake magazines. The Southern Ry. Co. had hardly been organized before a skilful campaign of publicity began. Not only the capitalists of other sections of the country, but also the thrifty people of small means began to recognize that there were great opportunities along the lines of that system, and this knowledge was imparted by machinery set in motion by Mr. Spencer. He recognized as few men of such high position have done that a publicity campaign is a powerful agent. He used it to build up the communities along his railway lines and he again used it so effectively a year ago that President Roosevelt was forced by public sentiment to abandon a cherished feature of his scheme for regulating railway rates. The publicity work of the railway was organized as a business matter. The company had transportation for sale, and it was desirable to get just as many customers for that transportation as possible. In order to have more steady customers, rather than the temporary tourist class, it was necessary to build up industries and develop natural resources along the lines. As a consequence the railway company became a press agent for the South, and directly and indirectly has exerted a tremendous influence in its improvement, as was to be expected from an organization directed by a man who was bound to that section by birth, had fought for it as a youth, and worked for it as only a man of great ability and a high sense of responsibility can work.

The Engineer-Constructor.

An interesting paper by Mr. George A. Damon on the "engineer-constructor" was printed in this journal last week, together with some comments on the business aspects of combined engineering and contracting work. There are other aspects of the paper, however, which deserve comment. For instance it is a worthy thing to add to the importance and dignity of any business or profession, but The Engineering Record has some doubts, however, whether this can be done by any purely verbal process, and it must confess to some wholly good-natured amusement at any attempt to construct a euphemistic bridge between engineering as such and contracting as such. The contracting engineer as distinguished from the consulting engineer is already a most useful and highly respected member of society; the contractor likewise is a usually competent man engaged in an entirely honorable business for which no apologies need be offered. Why then introduce a new term to designate an old function, however well carried out? No play upon professional nomenclature can obliterate the fact that an engineer who engages for gain in the actual business of contracting is anything else than a contracting engineer, differing from a plain contractor in that he is supposed to have in his own proper person or upon his staff regularly that technical ability which the everyday contractor has well learned to call in when he needs it. The day has gone by in which an unskilled contractor can get anything but the roughest work unless he strengthens his hands by securing competent advice, and when he has done this he has put himself for the time being in as good position technically as anybody else. How much technically skilled assistance he finds it useful to retain permanently is merely a business detail.

There are, of course, large engineering firms whose regular business is contracting and very admirable work they sometimes do. It would be a little difficult to explain, however, in what particulars they stand in a different class from the large contractor who plans and carries out his work under the advice of an equally competent firm of consulting engineers. Each makes his profit out of the execution of his work, and, if he does his work well, is entitled to equal credit. If the "engineering" firm is more capable than the "contractor" and his advisers, it is likely to get ahead, otherwise it will not. There is no common ground on which the consulting engineer in his own proper function and the contracting engineer can stand. They are separated exactly as is the architect from the builder, each making his gain from his own proper work. An architect constructor is just a plain technically skilled contractor who specializes on buildings. He may or may not be a suitable person to employ in his duplex function, but Mr. Shadrach Meshach Jones, architect, and Mr. S. Meshach Jones, builder, are one and the same person with interests which are inseparable, and that is all there is to the matter. He may be properly called in as adviser in either of his functions, when and if the other function is temporarily eliminated, if the fact can be ascertained. He certainly has the merit of conducting his business openly and not taking a rake-off from each side on the quiet, as do some who make higher pretensions to judicial functions.

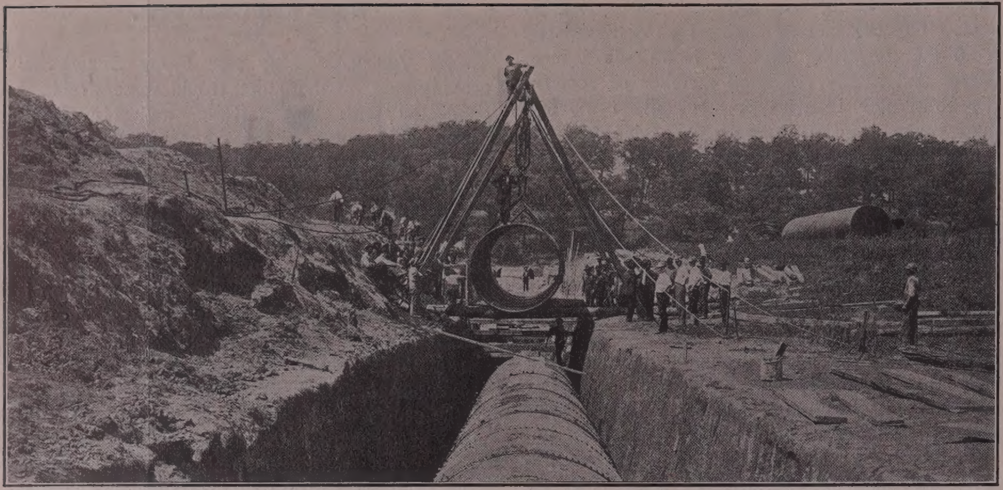
The whole story is that to-day successful contracting requires a very considerable degree of technical skill which some one must be prepared to furnish. Contracting is a reputable business of which no man need be ashamed, nor is it necessary to his dignity that it should be disguised behind any circumlocutions. The work of the trained engineer in guiding construction, whether in behalf of a firm of contracting engineers or as adviser to one who calls himself simply a contractor, is highly important and it is a line of work to which many young men should look forward. Our technical schools might well lay greater stress on this phase of engineering, for it is not easy to find men well trained in it. A dozen designing engineers can keep a hundred busy in the field. Engineering education has been directed in far too great measure toward lines which furnish but a very small number of suitable places, to the neglect of the wider spheres of action which call for quite as much ability and furnish much better chance of permanent and profitable occupation. Give wider opportunity to the engineer who executes, by whatever name he may be called.

Notes and Comments.

The Ventilation of the Paris Subway is proving one of the most troublesome problems connected with that railway, and Mr. Louis Biette, chief engineer of the company, recently stated that a complete solution had not yet been reached. Outlets cut through to the surface have been tried at two stations and a tall chimney has been used to induce draft at another place, but these expedients have not been particularly satisfactory. Some form of mechanical ventilation is considered most promising, and a large electrically-driven fan is now being tried near one of the stations. The difficulty anticipated is the production of drafts too strong for the comfort of the people on the station platforms. It should be some consolation to the people of New York, that the same ventilation problems have arisen in Paris as there, and the engineers are finding that a good deal of experimenting is necessary to reach a satisfactory solution.

Trade Names for Roofing Plate will be revolutionized by the recent decision of the American Sheet & Tin Plate Co. to stamp each sheet of such plate with the amount of coating it carries per box of 20x28-in. size. This will do away with the meaningless confusion of terms which have been a nuisance to those buying such material. Most of these terms long ago ceased to bear their original signification, and it is a good thing they have been abolished by such a strong company, for other manufacturers will doubtless be glad to adopt the same course. It has also been decided to stamp every waster plate "waster," so that the roofer and the owner of a house will know just what he is getting. There has been a good deal of complaint in the past that purchasers of roofing plate had no means of knowing what they were getting, but this new system of marking each plate with the amount of its coating and with its grade if it is not standard plate answers all requirements. It is a good indication of the tendency to free business from the defects it inherited from the past and to put the customer in possession of the information he has a right to expect.

Litigation Over a Reservoir Contract in the U. S. Circuit Court for the Western Pennsylvania district has resulted in an important decision, given in 146 Fed. Rep. 441. A contract with a city for the construction of a reservoir gave the city the right, if in the opinion of the Director of Public Works there was undue delay in the work or a failure to comply with the contract in good faith, to stop the contractor's work and complete the construction at his expense, the contractor to be entitled to any excess of the amount due him under the contract above the cost of completion and liable for any deficiency. It also contained a provision that any dispute arising between the parties under the contract should be submitted to the Director of Public Works as arbitrator, whose decision should be final and conclusive. In this case, the Director stopped the work and completed the construction. This action, the court rules, was a waiver of the arbitration clause and the contractor could not be compelled to submit the question of the amount due after the work was finished to the Director as arbitrator, but was entitled to maintain an action for it in the courts. The court further ruled that in such an action the burden does not rest on the contractor to show the cost of the work done by the city in completing the contract, there being no presumption that such work exceeded the prices specifically fixed by the contract for the work so done; moreover, any excess of cost is a matter of affirmative defense by the city in an action against it by the contractor, for it is a matter peculiarly within the knowledge of the city.



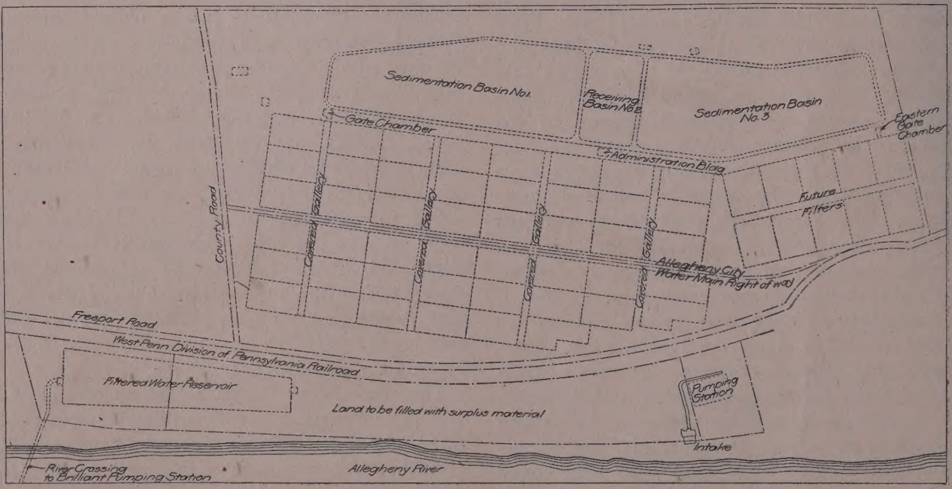
Laying 96-in. Riser Main from Pumping Station.

THE PITTSBURGH FILTRATION PLANT.—I.

The slow-sand filtration plant which is being built to treat the water supply of Pittsburgh, Pa., is more than 50 per cent. completed, and with a good winter season will be finished ready for operation on contract time, Sept. 1, 1907. This plant will have forty-six covered filter beds, each with a net filtering area of an acre, together with the necessary pumping station, sedimentation basins, filtered-water reservoir, connections and appurtenances, and will be the largest plant of this kind that has been constructed. It will have a net capacity of approximately 100,000,000 gal. of filtered water per day under normal operating conditions, based on a maximum rate of filtration of 3,000,000 gal. per acre per 24 hr., and after allowances have been made for beds out of service for cleaning or other reasons. All piping connections, conduits, regulating devices and so forth have been designed, however, for greater capacities to provide for growth. General plans have been prepared also for ten additional filter beds, each with an area of an acre, for which space exists in the easterly portion of the site already owned by the city.

The construction of this plant is the outcome of a movement, started in 1893 by various civic organizations of Pittsburgh, to secure a better water supply for the city than was afforded by the turbid and polluted water of the Allegheny River, from which the municipal supply has always been drawn. Changes of administration and various other political difficulties interfered with the success of the movement to such an extent, however, that it was almost 12 years after the movement was begun before actual construction work on a purification plant was started. During the latter part of 1895 and 1896 experiments were conducted with a small sand filter by one of the civic organizations, the results of which caused a public agitation that brought about the appointment of a filtration commission comprised of eleven citizens. Under the direction of this commission, investigations were conducted to ascertain the pollution of the Allegheny River water, the possibility of securing a gravity supply of good quality, the adaptability of different types of filters to the Allegheny River water and various other matters concerning the improvement of the water supply. The results of all of these investigations were made public in a report issued in January, 1899, with the recommendation that a slow sand filtration system of an average daily capacity of 50,000,000 gal. be built, and that the Allegheny River be retained as a source of supply. In the fall of that year a $2,500,000 bond issue was authorized by popular vote to provide funds to carry out this recommendation, and during the next two years surveys were made and the preparation of plans for the plant was in progress. Invitations for proposals for the construction of the filter-bed portion of the plant, about 60 per cent. of the work, were sent out in January, 1902. These proposals were received, but the contract was never awarded, for on Feb. 24 of that year an injunction was granted by the federal courts which prevented such award. This decision of the court was based on the fact of a non-compliance with the requirements of the charter of the city making it a necessity that the city council should be in possession of the plans, specifications and estimates of the entire project and not of a portion before a contract could be awarded.

The preparation of plans and estimates was continued, however, and in September of that year a report was made to the city councils giving the estimated cost of the whole work. This report was referred to a committee of the councils in which it remained until August, 1903. At that date, pursuant to a resolution of the city councils, a report was made on the cost of a complete plant, large enough to furnish all the city with water, a large section of the city dependent on a private water company for its supply having been omitted in previous plans. The plans on which the report was made also included preparations for covered filters, whereas the previous plans had been for open ones. The total cost of the filtration system and the augmented water supply according to these new estimates would be $7,152,000.



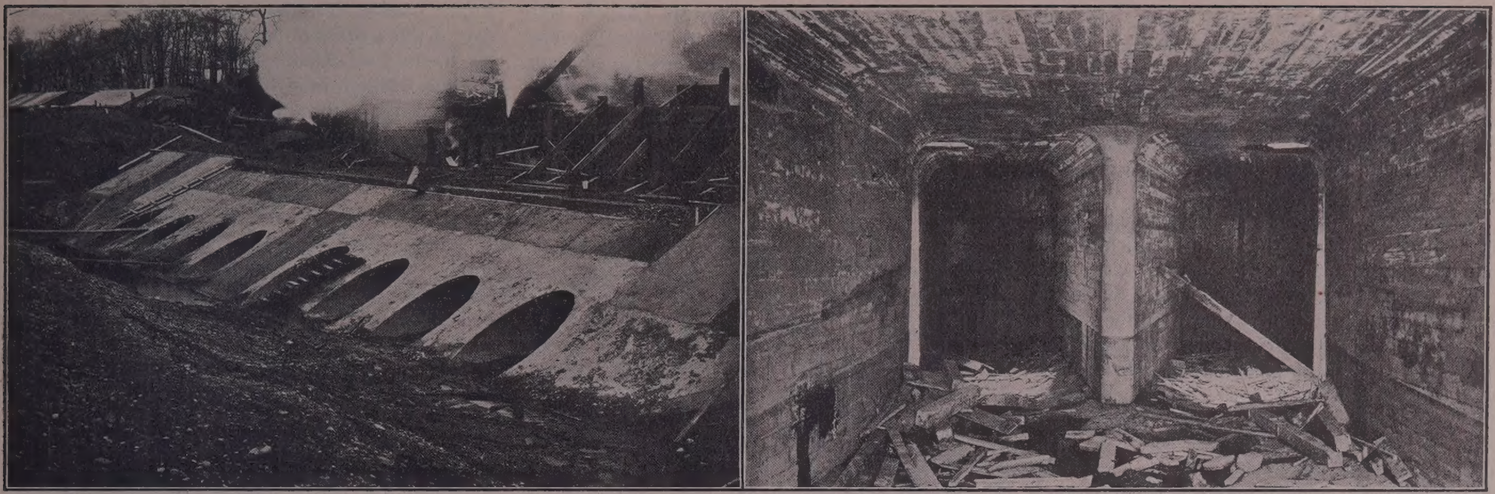
General Plan of Water Filtration Plant at Pittsburgh, Pa.

This increase in cost over the original estimates caused some criticism, so the city councils authorized a review of the second estimates by a board of engineers consisting of Col. A. M. Miller and Messrs. Rudolph Hering and John W. Hill. This board, in a report presented March 4, 1905, gave its approval of the whole project, so accordingly a bureau of the Department of Public Works of the city was established and an organization started May 1, 1904, to prepare plans and specifications for the $7,000,000 of work contemplated by the new estimates. During the following eight months complete detail plans and specifications covering the entire project were made. Invitations for proposals for construction were sent out in January, 1905, and the contracts for building the entire system were awarded to T. A. Gillespie & Co., March 12, 1905.

The plans for the plant first proposed were described in The Engineering Record of Jan. 25, 1902, and the conditions leading to their modification were outlined in the issues of Sept. 19, 1903, and March 5, 1904. A brief general description of the entire system as covered by the new plans was printed in The Engineering Record of Feb. 4, 1905. Inasmuch as some of the contract plans have been supplemented and further detailed since the latter date, and as a complete description of the entire plant and the manner in which it is being constructed will be printed in this and the following issues of this journal, some portions of the former description will be elaborated.

The city of Pittsburgh is on a narrow neck of land between the Monongahela and Allegheny Rivers, the two streams uniting at the lower end of the city to form the Ohio River. The filtration plant is on the right bank of the Allegheny River, seven miles from the junction of the latter with the Monongahela and well above the city. The valley of the river is largely rolling country, with hills that extend out nearly to the banks of the stream. Opposite and a short distance above the pumping station, at Brilliant, from which the city is at present supplied, however, is a practically level area, lying along the river, that is about 1½ miles long and ¼ to ½ mile in width. The edge of this tract along the bank of the river was mostly all above the highest flood level that has thus far been reached in the river, which level is at about El. 41 as referred to Pittsburgh city datum. The low-water stage of the river is at El. 14 as referred to the same datum. The construction of a dam across the river about ½ mile below the site will maintain a pool level at El. 24.5, and will probably raise the flood level to El. 43. The ground surface of the site formerly raised slowly from the bank of the river to the edge of the hills, the latter being about ½ mile back at the site.

General Plan.—The general plan of the plant



Views Showing Lower Row of Inlet Conduits at Intake and Intersection of Pair of 6x6-ft. Conduits from Gate Chamber.

is shown in one of the accompanying illustrations. Low-lift pumps in a station building on the river bank at the up-stream corner of the site raise the raw river water to a central receiving, or sedimentation, basin having a capacity of 20,000,000 gal. On each side of this receiving basin is a larger sedimentation basin, the combined capacity of the three basins being about 150,000,000 gal. The usual method of operation will be for the water to pass from this central receiving basin into both of the larger basins and then from the latter to the filters. From the filters the water is conveyed to a covered filtered-water reservoir on the bank of the river. Two steel conduits laid under the river connect this filtered-water reservoir with the existing high-service pumping station at Brilliant, from which the water is raised to storage reservoirs that supply the distribution system of the city. The water flows through the plant by gravity from the receiving sedimentation basin to the pumping station at Brilliant.

The topography of the site is such that various parts of the plant could be designed almost as desired except for the slightly irregular shape of the large sedimentation basins necessitated by the sides of the basins extending into the hill. An 18-ft. right-of-way for a 60-in. steel rising main leading through the site from a municipal pumping station of Allegheny, Pa., largely determined the arrangement of the filter beds, but not in a manner that was at all unsatisfactory. The shape of the filtered-water reservoir was also determined by the right-of-way of the West Penn division of the Pennsylvania R. R., which extends along the river bank between that reservoir and the main part of the plant.

Intake.—The pumping station is on the bank of the river at the upstream corner of the site on the river side, outside of the railroad right-of-way and about 100 ft. from the edge of the water. A heavy concrete revetment along the upstream corner and along in front of the site on which the station is built protects the banks from erosion and the station from floods. The intake through which raw water is admitted from the river to the conduits supplying the pumps that raise this water to the sedimentation basins is built just back of this revetment with inlet conduits extending through the latter. The plan of this intake and a cross section through one wall of it are shown in the accompanying illustrations.

The intake consists essentially of a concrete chamber, 69 ft. 7 in. x 33 ft. 9 in. in plan in extreme dimensions, and extending 2 ft. above high water with a total height of 49 ft. It is divided transversely into two duplicate halves which are designed so they may be operated separately when desired. Sixteen 4-ft. circular concrete conduits, having their outer ends flush with the 1 on 2 slope on which the revetment is built, admit water to two 12x28-ft. chambers back of the revetment. These conduits are in two horizontal rows of eight each, the lower row extending out beyond the low-water line, while the inverts of the upper row are 8.5 ft. above the inverts of the lower row. The two 12x28-ft. receiving chambers are entirely distinct and are each supplied by four conduits in each of the two horizontal rows.

The inner end of each of the conduits in the upper row is connected by a vertical shaft with the inner end of the corresponding conduit in the lower row. The conduits in the lower row, only, extend into the receiving chambers through the outer wall of the latter. The flow through each conduit can be cut off with stop planks, however, and water drawn from either or both elevations according to the condition of the river water. Each of the conduit openings in the receiving basins is controlled by a sluice-gate operated manually through a ball-bearing stand on top of the intake. A 30-in. pressure main from the pumping station connects with a conduit, built longitudinally in the outer wall of the receiving chambers, 10 ft. above the lower row of conduits. This conduit is connected to each of the inlet conduits in the lower row so that by closing the sluice gates and properly placing stop planks accumulations of mud or debris may be flushed out of any one of the sixteen conduits.

The receiving chambers are of such size that the heavier materials coming in through the inlet conduits will be deposited in them. The outlet from both receiving chambers is a 6x9-ft. channel, the two channels merging into a single 124-in. conduit, built of concrete, that leads to the pumping station. The flow through both of the 6x9-ft. conduits is controlled by a 6x9-ft. sluice gate so that either chamber may be cut out of service without interfering with the flow through the other. Stop planks on both sides of these gates permit the same results to be secured in an emergency.

The 124-in. conduit extends from the intake back inland to the inshore downstream corner of the pumping station, with a total length of about 230 ft. At this point it divides into two 100-in. conduits, one of which leads into the pumping station that is being erected; the other branch is provided to supply an additional station and for the present has been bulkheaded.

The Pumping Station.—The pumping station is in a single-story building, 128 x 200 ft. in plan,

Inlet Conduit and Slope Lining for Westerly Sedimentation Basin and Construction of Revetment Blocks Over Slope Lining.

with a longitudinal wall at the center which divides it into two rooms, one in the rear on the river side for the boilers and the other for the engines and auxiliary machinery, the structure facing the remainder of the filter plant across the railroad tracks. It has concrete footings and a superstructure of vitrified pressed gray brick trimmed with Cleveland sandstone and is of fireproof construction. The radial brick of the stack were made to match the vitrified brick of the building exterior at some trouble and expense.

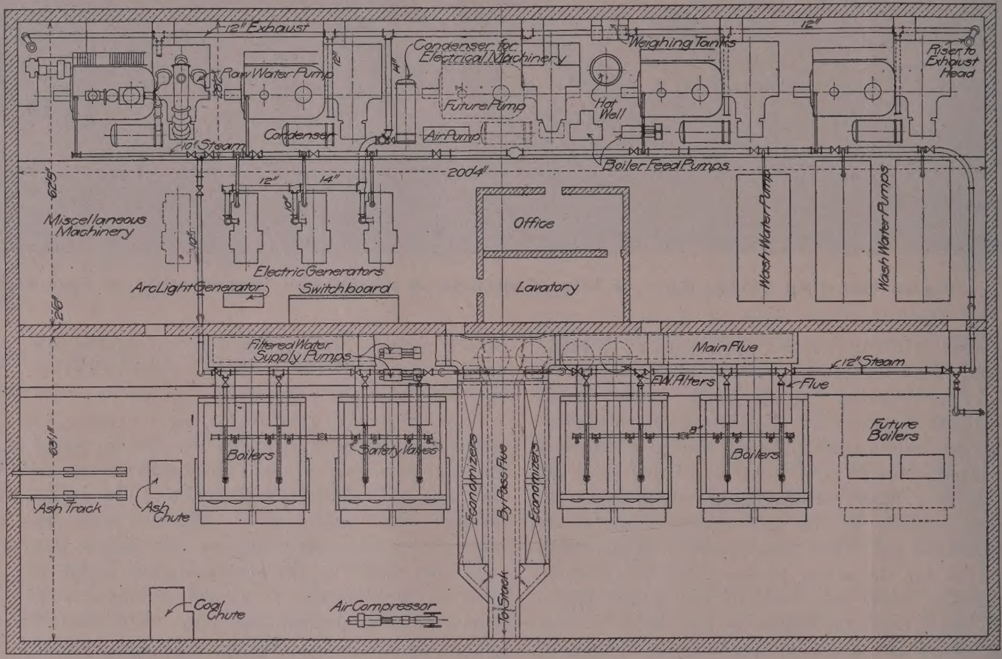
The arrangement of the boiler and machinery equipment of the station is shown in the accompanying general plan. The boiler-room will contain eight 350-h.-p., horizontally inclined, water-tube boilers built by the Sterling Consolidated Boiler Co. These boilers are in pairs as shown, with space provided for an additional pair. The furnaces of the boilers will be equipped with Mansfield chain-grate stokers. Two 360-tube Green economizers will be located between the two middle pairs of boilers on an overhead steel frame carried by columns and by the rear and dividing walls of the building. The gases from the boiler furnaces will normally be directed through these economizers and thence to a Custodis radial brick stack, 200 ft. high above the furnace grates and with an internal diameter of about 8 ft. Provisions are also made to by-pass these economizers and conduct the furnace gases directly to the stack.

The chain-grate stokers are supplied from coal bunkers erected on a steel frame over the firing floor of the boiler room. Coal is delivered to the station in cars on a railroad siding extended along the rear of the building. A hopper under this siding connects with a concrete-lined pit under one corner of the floor of the boiler room. Coal is conveyed from this hopper up an inclined track in a bucket and thence along a trolley over the bunkers in the same bucket. The stokers are supplied by gravity from the bunkers. The ashes from the grates fall into hoppers having a storage capacity of about one day's production. These hoppers are connected with a 7x9-ft. concrete-lined tunnel extending longitudinally under the boilers and the ashes are discharged from them into a bucket on a truck in this tunnel. This truck is pushed to the end of the tunnel, which is at the end of the boiler settings, by hand and the bucket hoisted through a shaft and dumped into a car on a track at the level of the boiler-room floor. A compressed-air locomotive hauls the loaded cars to a dump near the building.

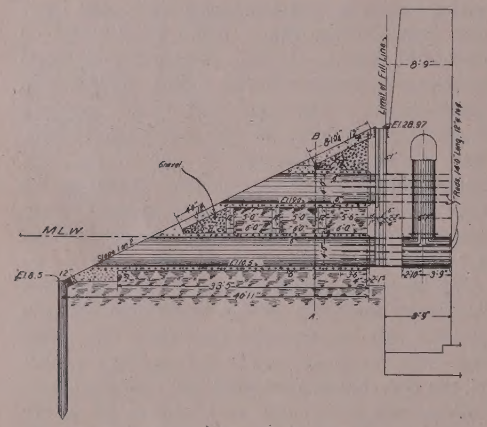
The engine room of the station building has a pump pit, 28 ft. wide and with its floor 16 ft. below the floor of the remainder of the room. This pit is provided for four horizontal single-stage, double-suction, Allis-Chalmers centrifugal pumps, each direct-connected to a vertical, cross-compound, Allis-Chalmers Corliss engine. These pumps raise the raw water from the river to the sedimentation basins. Each of them is designed to have a total capacity of 35,000,000 gal. in 24 hr. when pumping against a total head of 60 ft. and a capacity of 55,000,000 gal. in 24 hr. when pumping against a total head of 30 ft. The average head against which they will operate will be about 46 ft. The suction lift varies with the height of the river, but the construction of the dam a short distance below the plant will reduce the lift to a maximum of 4 ft. Space is provided for the addition of a fifth unit of the same size and capacity as these four.

The 100-in. branch of the 124-in. conduit leading from the intake extends longitudinally under the footing of the front wall of the building and under the pump pit, forming a suction trunk to which each of the raw-water pumps is connected. These pumps discharge through a branch connection into a 96-in. rising main, 1,853 ft. long, leading to a gate house in which the flow to the sedimentation basins is controlled. Each of these connections is controlled by an electrically operated gate valve in the pumping station and by a check valve in a valve chamber outside the building. The flow through the rising main is measured near the corner of the station building by a 96-in. Venturi meter with a 50-in. throat, which is the largest meter of this type that has been built. The main is controlled by a hydraulically operated 72-in. gate placed just back of this meter.

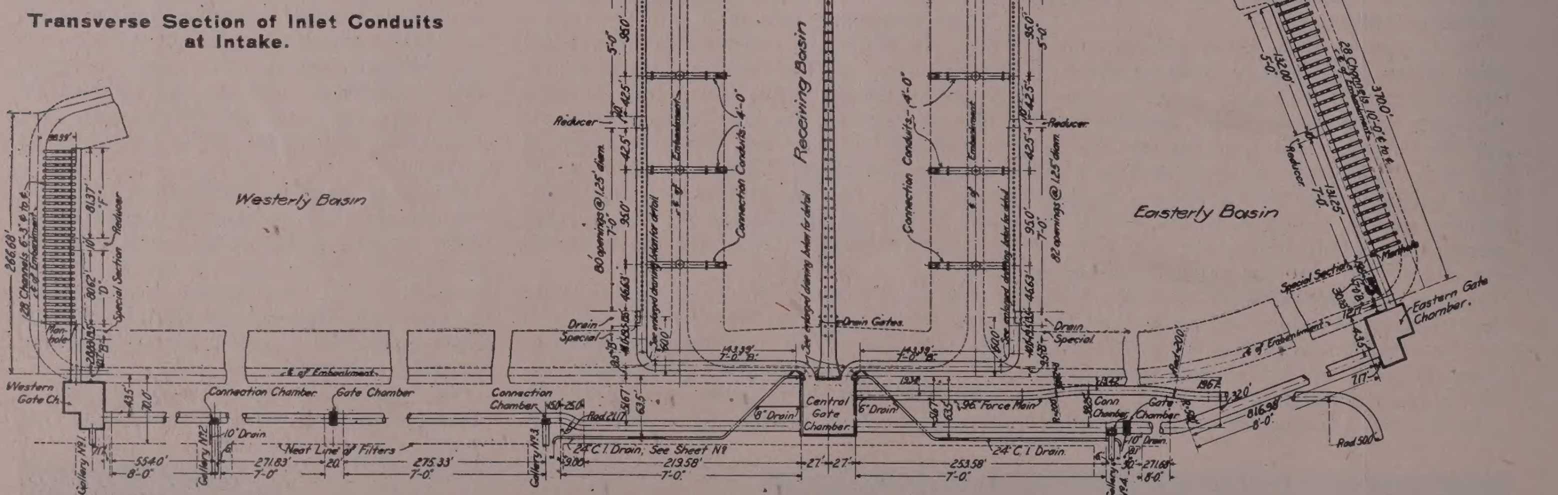
The 96-in. rising main is built of ½-in. steel plates and is surrounded by concrete to resist



General Plan of Pumping Plant.



Transverse Section of Inlet Conduits at Intake.



Plan of Inlet and Outlet Conduits for Sedimentation Basins.

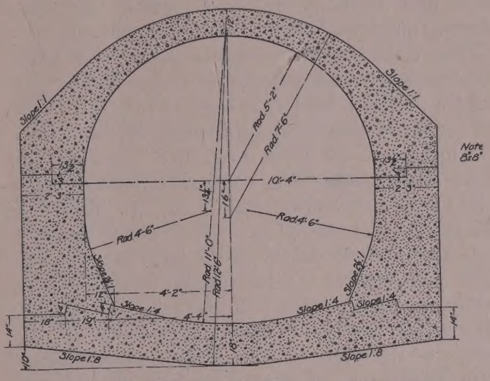
deformation by earth pressure. This concrete casing consists of 1:3:7 concrete and is not reinforced. All of the force mains throughout the plant are built of riveted steel plates and are protected where necessary with concrete.

The standard type of conduit used throughout the plant for conveying water under low heads and where a cross-section is greater than that of a 5-ft. circular pipe is required is shown in the accompanying cross-section of the 124-in. conduit from the intake to the pumping station. This standard type has a semi-circular arch top, vertical sides and an invert composed of the arcs of three circles merged into a compound curve. When loaded heavily, or where built under embankments, these conduits are made of 1:2:4 concrete and are reinforced.

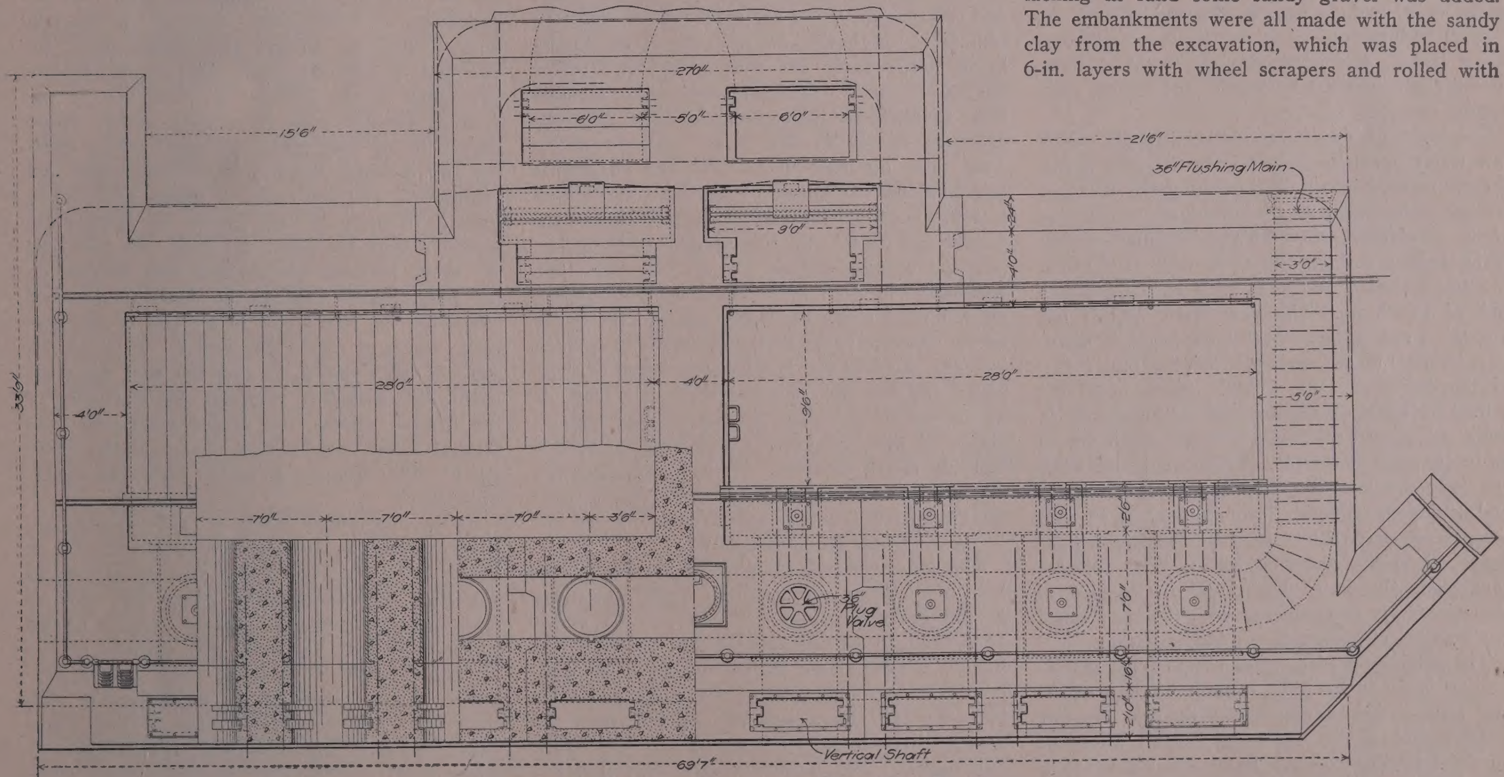
A 3,000,000-gal. tandem compound D'Auria pumping engine and two 5,000,000-gal. units of the same type, all of which are being built by the Builders Iron Foundry Co., of Providence, R. I., will furnish water at 100-lb. pressure for washing the sand scraped from the filter beds and to a high-pressure distribution system that extends to all parts of the plant. These pumps may be supplied either with settled water from the sedimentation basins, or with filtered water from the conduit leading from the filters to the filtered-water reservoir. Filtered water for drinking purposes and for work in the laboratories will be supplied through a distribution system extending throughout the plant by a 6x7x12-in. duplex pumping engine built by the Platt Iron Works.

The filtration plant has various auxiliary machines and pieces of equipment arranged to be operated by electric motors. These motors will be supplied with direct current by three 175-kw., three-wire Westinghouse generators each direct-connected to a 250-h.-p., cross-compound Shepherd engine. A motor-driven generator capable of producing 6.6 amperes at 5,000 volts will furnish alternating current to light the arc lights on the grounds of the plant.

All of the steam-consuming units in the station except the wash-water pumps will be operated condensing, Wheeler surface condensers being employed. Water will be circulated through these condensers by a 12-in. Lawrence centrifugal pump driven by a 25-h.-p. Westinghouse motor. For the wash-water units the condensers are in the suction mains.



Cross Section of 124-in. Conduit.



Plan of Intake, Pittsburgh Filtration Plant.

Feed water is supplied to the boilers from a hot well in the machinery room by either of two pumps. One of these is a 7x8-in. duplex pump driven by a 25-h.-p. Westinghouse motor, the other is a 10x7x12-in. steam pumping engine, so that feed water can be supplied under any conditions of service. Both of these pumps were built by the Platt Iron Works.

The steam-supply piping is on the ring system. The boilers each connect with a 12-in. header placed along the rear of the boiler settings. This 12-in. header connects at each end with a 10-in. header in the engine-room to which the various engines are connected. The exhaust piping is arranged so the units may all be operated non-condensing and exhaust to the atmosphere. The exhaust will also be automatically directed into the atmosphere when the pressure in the condensers exceeds a certain amount. A 12-in. exhaust header is placed longitudinally the length of the pit and connects at one end to a riser pipe extending above the roof. The exhaust pipes of all of the steam-consuming units will have connections with this header.

Central Gate Chamber and Sedimentation Basins.—The 96-in. rising main from the pumping station extends to a central gate chamber at the middle of one end of the central, or receiving sedimentation basin. This gate chamber, 50 x 53.5 ft. in plan, is built of concrete and is carried by 200 Simplex concrete piles. In it are placed the gates controlling the flow of the water in the conduits leading into and away from the sedimentation basins. A three-story administration building from which the operation of the entire plant will be directed and controlled is built over this gate chamber.

The three sedimentation basins with their combined capacity of about 150,000,000 gal., which is equal to 36-hr. storage for the portion of the filter plant that is now being constructed, are built partly in excavation and partly in embankments. The central or receiving basin is a regular rectangle, while the two large basins are built to fit the contours of the site and are both slightly irregular in shape. The basins have a total depth of 19.25 ft. from the top of the lining of the bottom to the top of the embankment around them. The maximum depth of water in them will be 15 ft. The soil of the site on which they are built is for the most part, after the top soil is stripped, a good clay with just enough sand in it to form an excellent puddle material for embankments. The top soil was removed in all cases and where the clay was below the grade of the bottom of the basins material from excavation in other portions of the site was filled in and rolled with steam rollers until the site was brought to grade. In places where the clay was lacking in sand some sandy gravel was added. The embankments were all made with the sandy clay from the excavation, which was placed in 6-in. layers with wheel scrapers and rolled with traction engines. These embankments are all made several months in advance of the placing of any protection on them.

The bottom of the basins is lined with 6 in. of 1:2:4 concrete which was laid directly on the clay bottom, prepared as described, and finished with a 1-in. coat of 1:3 mortar. The lining of the bottom of the receiving basin and of the sedimentation basin to the west of it have been completed and have been laid in alternate checkerboard squares, 10 ft. one side, and the remaining squares filled in later. A projection 2 in. wide and 4 in. high was made on all four sides of each of the first 10-ft. squares laid to form a joint with the other squares that would be tight and at the same time permit lateral movement of the squares.

The inner sides of all the basin embankments are built on a 1 on 2 slope and the outer sides on a 1 on 1½ slope. The 6-in. concrete lining on the bottom is continued up on the inner slopes of the sides of the reservoir to within 1.75 ft. of the top of the slope. A berm 5.6 ft. wide is made in this lining 7 ft. above the bottom of the reservoir. Above this berm an 18-in. layer of gravel is placed over the 6-in. layer of concrete, and on this gravel is a revetment consisting of concrete blocks 7 ft. square in plan and 12 in. thick which extends 1.5 ft. above high-water level in the reservoir. In placing the lining of the reservoir and the revetment on the embankments the 6-in. lining is usually carried up to the berm in alternate sections about 10 ft. wide. Then the blocks at the outer edge of the berm are placed and finally the portion of the lining above these berm blocks is laid in alternate sections 10 ft. wide. The 18-in. of gravel is then put in place and the 7-ft. squares laid. Where the slope of the side of the reservoir is in excavation it is protected in the same manner as on the embankments. In all wet places in excavation weep holes are placed in the concrete lining on the slopes.

The arrangement of the inlet and outlet connections of the sedimentation basins is shown in one of the accompanying illustrations. The 96-in. rising main enters the gate chamber at one corner, its inlet being controlled by a 6x9-ft. sluice gate operated electrically from the floor above. Under normal operating conditions, the water will pass from the chamber into which the 96-in. riser main connects through a pair of 6x9-ft. conduits leading to the receiving sedimentation basin. The flow through both of these conduits is controlled by 6x9-ft. sluice gates electrically operated.

The pair of 6x9-ft. conduits through which raw water normally passes from the gate chamber are merged into a single rectangular concrete conduit built along the longitudinal center line of the receiving basin. This rectangular conduit varies from 9 ft. high and 12 ft. wide at the inlet end to 4 ft. high and 4 ft. wide at the opposite end of the basin. The raw water passes out through a row of bell-mouth holes 18 in. in diameter at the top, on each side of the center line of the cover of the conduit. These holes are 9 ft. 8 in. apart on centers and in the end 87 ft. there is a single row only of them which are 24 in. in diameter at the top. These numerous holes are expected to completely reduce the velocity and turbulence of the incoming water so that the greater part of the suspended matter will be deposited in the receiving basin. With this arrangement the latter basin will be cleaned at short intervals as compared with the time elapsing between cleanings of the larger basins.

The partially settled water passes from the receiving basin to the inlet conduit of each of the two large sedimentation basins through the side embankment of the receiving basin. The four conduits leading to each basin are 100 ft. apart on centers and each of them is controlled by a 36-in. valve placed in a chamber in the embankment of the basin. The ends of these 48-in. conduits in the receiving basin have a concrete box, 4 x 6 ft. in plan and 7.5 ft. high above the bottom of the basin built around them. The top of these boxes are omitted so that the water enters the conduits from the 8-ft. level and all accumulated sediment is held back in the basin.

When the receiving basin is being cleaned or is out of commission for any reason the two 6x9-ft. sluice gates controlling the conduit leading into it from the central gate chamber are closed. A 7-ft. conduit of the standard general type adopted for use throughout the plant is extended from the central gate chamber to the inlet conduit of each of the large sedimentation basins. The inlet conduit to each of these basins is built at the inner toe of the slope of the embankment on the end next to the receiving basin and extends across that end the full width of the basin. Starting at the gate chamber, these conduits are of the standard 7-ft. type, which size is continued about three-fifths of the width of the basin and then reduced to 5 ft. The partially settled water from the receiving basin, or in case that basin is out of service the raw water from the gate chamber, passes into the basin from the conduit in both cases through a row of seventy-nine circular holes 15 in. in diameter made in one side of the top of the conduit. The tops of these holes are flush with the top surface of revetment paving of the slope of the embankment of the basin. The holes are so arranged that the flow into the basin will be completely and uniformly distributed and all currents avoided.

The settled water is drawn from both large basins at the end opposite from the end across which the inlet conduit is built so that the water is caused to pass the entire length of the basins, or in each basin about 1,200 ft. The outlet in both cases consists of a concrete conduit of standard type and varying from 5 to 7 ft. in size as in the case of the inlets. These outlet conduits are each built in the toe of the inner slope of the end embankment of the basin. The inlets to these conduits consist of channels in concrete boxes laid in the revetment protection of the slope of the embankment. These concrete boxes are 18 in. deep and 30 in. wide, over all, and provide a channel 12 x 24 in. in cross-section. Twenty-eight of them are provided in the outlet end of each basin, and are spaced 6.5 ft. apart on centers in one basin and 10 ft. apart on centers in the other basin, the ends of the two basins varying in width. The concrete boxes forming these channels are tight except for these 24x24-in. openings spaced so that water may be drawn from three different levels. The top opening is 12.5 ft. above the bottom of the basin, the second is 3 ft. lower and the bottom one 3 ft. below the second and 6.5 ft. above the bottom of the basin. The top opening has no cover. The other two openings will each be covered by a sheet-iron plate, hinged along the upper edge to the inside of the concrete cover of the channel and opening inward. An iron rod is attached to each of these plates and the two rods extended to a manhole at the top of the slope so that the openings at either of the two lower levels may be opened from the top of the slope. With this arrangement, water may be drawn from the lowel levels while the river water is low in turbidity and several feet of head against the pumps saved.

The outlet conduits carrying settled water from both of the large sedimentation basins lead along in the embankment on the side of the basins to the central gate chamber where they join. A branch is taken from the conduit from the eastern basin to supply part of the filters and three branches are taken from the conduit from the western basin to supply filters on that side of the gate house. The normal method of operation, however, will be to supply two of these branches from one basin and the other two from the other, but all four branches may be supplied from either basin in case the other basin is out of service. Gates in the conduit also permit sections of them to be cut out of service and cleaned. A gate chamber on each of the settled-water conduits at the corner of the basins distant from the central gate chamber also provides for supplying settled water to additional filters.

The sedimentation basins are all designed so they may be drained and cleaned with little difficulty. The bottom of the receiving basins on both sides of the inlet conduit is graded to two sumps near the inlet end of the basin. These sumps are each connected through openings in the walls of the inlet conduit controlled by sluice gates with a 24-in. cast-iron pipe leading to the drainage system of the plant. The other two basins are also both connected with this drain through two 24-in. openings in the side walls of their inlet conduits in the portion of the latter near the central gate chamber. These openings are also controlled by sluice gates, the gates controlling all drainage openings being in chambers just back of the central gate chamber. Drainage openings are made in the side of the inlet conduit of each of the large basins just inside the slope at the corner of the basin and are controlled by stop planks. The bottom of each of these basins has a fall on a uniform slope of 1.5 ft. from the corner diagonally opposite the drainage openings to the latter. This arrangement of drainage openings permits accumulated sediment to be cleaned readily from the three basins.

(To be continued.)

Saw-Tooth Roofs.

Two of the papers presented at the meeting of the American Society of Mechanical Engineers this week related to saw-tooth or weave-shed roofs. The author of one of these papers, Mr. Fred S. Hinds, of Boston, stated that he first designed one of these roofs in 1885, when he had to put up a one-story building in a yard formed by three buildings which had a combined U-shaped plan. The problem was to light this area and project light into the first story of the existing buildings so as to make up for the loss of light due to roofing the yard. An examination of a saw-tooth roof of the English type showed that leakage was taking place. In this type of roof the acute angle formed by the two sides of the skylight was finished in the form of a gutter, made up of sheet metal. These gutters fill up with snow and water which, melting and freezing, cause excessive expansion and contraction, and the result is cracks and broken joints. Profiting by this lesson, Mr. Hinds designed a semi-saw-tooth flat roof. In this type the space between the skylight was finished in the usual gravel roofing, the slant of the roof conveying the roof-water to the end of the skylight, where it enters the gutter. In later designs he has reduced the wide flat roof space between the skylights, returning more closely to the English system, but at the same time preserving a flat roof between each skylight, varying in width from 24 to 48 in., according to circumstances.

As the prevailing winds in snow-storms are either from the northeast or northwest, it is found to be true (according to observations in a locality in Massachusetts where this style of skylight is very popular) that the wind in a high storm will blow the snow out, because of the somewhat funnel or grooved shape of the skylights. Even if they do fill up somewhat with snow, it is not a great expense to hire cheap labor to shovel out this snow, as through our whole winter period heavy storms are only occasional. The cost of shoveling out the snow is a very small expense, as compared to the enhanced value that fine lighting gives to the production of the plant.

With a monitor skylight, in a drifting storm, the vertical side would resist the snow and pile it up, and naturally get the same result as with the saw-tooth, according to Mr. Hinds. The advantage of the flat roof is that it spreads out the saw-tooth into a wider area and the snow cannot pile so deep as in the V form.

In a discussion of this paper, Prof. John E. Sweet stated that a saw-tooth roof of the English system built at the works of the Straight Line Engine Co., in 1889, had shown no trouble from leakage, because the gutters were made of cast-iron, short enough to go between the trusses, which are only 8 ft. apart on centers. Each trough was drained by a separate spout into a continuous conductor running from end to end of the building. As the troughs and conductor are inside the building and are of iron instead of wood, they melt out the snow before it melts on the roof and hence there is no trouble from ice and snow. The troughs are in sections with a joint cover, so that expansion and contraction have no detrimental effect. The spans are 32 ft., the trusses 8 ft. apart, and the glass 6 ft. high. During seventeen years of use, snow has had to be shoveled off but once, and then only because it piles up on the glass and shut out the light.

In the second paper on the subject, Mr. K. C. Richmond, of Providence, pointed out that north of the tropics the saw-tooth windows must face nearly north, and the angle of the sash with the vertical be made dependent on the latitude of the location, the angle increasing the further we go north. In the latitude of New York, about 41 deg., this would mean an angle of only 17 deg. to 18 deg., to keep out the sun in the longest summer days, were it not for the small projecting cornice above the window, and the internal stool or gutter at the bottom. These projections enable us to make the angle of the glass with the vertical greater than we otherwise could do, and with the form of setting and trimming frequently adopted, angles from 25 deg. to 30 deg. have proved satisfactory in practice in New York and New England. The angle of the glass with the vertical could be made much greater, and still keep out direct sunlight, if the cornice above the windows were extended, or a screen or barrier run along the crests of the saw-teeth. A very interesting modification of saw-tooth lighting on the above line has been made by Mr. Willard T. Hatch, in the treatment of foundry roofs, where he has placed the glass skylights on one side only of the successive ridges of the roof, and used the continuous ventilating monitors at the peak of the ridges, as a screen to keep direct sunlight off the glass, thus making the angle of the glass with the vertical much greater than would otherwise be possible, at the same time getting the benefit of the brighter light of the upper sky in much greater degree than would be the case were the same area of glass placed more nearly vertical.

Where the angle of the glass with the vertical is made greater than a theoretical consideration of the latitude permits, for the reasons above noted, and the windows face the north, it follows that at seasons when the sun rises and sets north of the equator, that there will be a little direct sunlight on the windows for a little while after 6 a. m., and also for a little while before 6 p. m., solar time being used in the reckoning. Mill hours in the North usually begin about 6.30 a. m. and end about 6.00 to 6.15 p. m., or, in other words, the help work a greater number of hours after mid-day than they do before it, and where the compass points of the building are not already determined by other considerations, we can avoid in a large measure the direct light of the late afternoon sun in summer by placing the building so that the saw-teeth will face from 5 deg. to 15 deg. east of north, and still not have trouble from direct sunlight before bell-time in the morning.

Any form of roof covering which successfully withstands the attacks of heat, cold, wind, rain, snow and ice, after it is applied to the steep pitch of the back of the saw-tooth, is available. Gravel roofs laid with crushed slag in asphalt, have successfully held on slopes as steep as 6 in. to the foot in the New England climate, and some of the prepared felted roofings have proved satisfactory. Good materials and extreme care in applying seem to be the secrets of good service on saw-tooth roofs as on others.

The usual arrangement of saw-teeth in roofs of large rooms, namely, successive rows of windows, facing north, with the backs of the saw-teeth, which form the roof proper, sloping down to the valley at the bottom of the next row of windows, makes the exposure to cold particularly severe, and due allowance must be made for this in the heating scheme. In textile mills where a relative humidity of 75 to 80, with temperatures about 80° Fahr., is desirable for manufacturing, the tendency to roof and window condensation in cold weather is very large and the usual plank roof is not of itself sufficient to prevent such condensation. Sometimes the planking has been furred and sheathed, dependence being placed on the air space between plank and sheathing to act as a non-conductor of heat, but Mr. Richmond's experience is that such sheathing is only partially effective, and that condensation is constantly taking place in very cold weather between the plank and sheathing, which works through the joints in the sheathing making drips and stains, and helps to rot both plank and sheathing. He has used a double layer of Cabot's sheathing quilt, made of dried sea-weed, between the plank and sheathing of a flat roof of a factory office, with satisfactory results, and at small expense, and the same treatment seems applicable to saw-tooth roofs. Any treatment which increases the insulating power of the roof against the passage of heat, and at the same time does not increase the fire hazard, or cause dirt after it is put in, will increase the comfort of the help in both cold and hot weather, with a lessened expense for heating in cold weather.

The portion of the front of the saw-tooth directly below the window stools, should be at least as thick and as well insulated as the backs of the saw-teeth, as this part of the roof forms one side of the valley between the lines of saw-teeth, and being out of the line of direct sunlight in the winter, snow will remain there longer than on other parts of the roof, with consequent chilling of the roof.

Frequently the sash are double glazed with an air space about three-quarters of an inch between the lights, and this is of undoubted value in keeping heat in the building in cold weather. One glazing is often done with "factory ribbed" glass, the ribs running lengthwise of the window, and the ribbed side placed toward the air space between the lights. The ribbed glass assists in the diffusion of the light, which is sometimes strong, even with a north exposure, due to deflection from clouds. In all cases where delicate shades are to be matched, insistence should be placed on having all the glazing done with white glass to avoid the green tint of the light coming from the ordinary glass, which shows green when looked at edgewise. In spite of double glazing, there will generally be some window condensation which must be taken care of by internal gutters at the bottom of the sash. Such gutters may drain into a system of internal piping, or have an outlet under the bottom of the sash itself, draining the condensation out on to the roof, the outlet being so arranged that the warmth of the building will keep it from freezing.

The ventilation and cooling in hot weather, of large rooms with saw-tooth roofs, where the height under the framing runs from about eleven to sixteen feet, is a question always needing attention in the design. Such roofs have been built where the sash in the saw-teeth were all fixed sash, and the side walls contained no windows, or only small ones, and ventilation was dependent on small windows in the ends of the saw-teeth, aided by such ventilation as came from a few entrances, and the movement of air through the belt holes in the floor. In hot and muggy weather such rooms became extremely uncomfortable, and some owners have since installed steamboat, or other, ventilators at the ridges of the saw-teeth with satisfactory results. Others have changed some of the fixed sash to pivoted or hinged sash, the chief objection to which is the difficulty of making them tight in driving storms, on account of their inclined position. In one case noted some of the fixed sash were simply removed, as there was little danger of water damaging the work in the room below. The common two-casement window can be readily adapted to saw-tooth skylights by extending the outer casings over the sash rims, and arranging for the upper half only to slide, and by balancing the upper half by spring lifts instead of weights. Revolving steamboat ventilators, with dampers in the flues, are easily placed at the ridges of the saw-teeth, and give good service, when made of material which withstands corrosion.

The flashing and draining of saw-tooth roofs have given trouble at times. The great length of flashing in the valleys between the saw-teeth gives opportunity for much expansion and contraction and the piling up of snow in the valleys, with a relatively warm roof melting it on the underside, gives a chance for water to work up over the lower flashing, unless the same is of ample height and very carefully put in, and provision made for promptly carrying off the water from the melting snow. Where the saw-teeth run across the building, the roof is often pitched from the center ridge to both sides on a slope of a quarter to half an inch per foot, and the water carried off in conductors which run down on the inside or the outside of the outside walls. Outside conductors have proved very undesirable in New England on account of the water freezing as soon as it has passed from the warm surface of the roof to the cold outside conductor. The result is a great mass of ice, and generally a broken conductor. It is altogether desirable, in climates where water freezes in the winter, to run the conductors down on the inner face of the side walls and to make both the strainers and conductors of ample capacity to carry off any probable amount of rain or melted snow.

Where the ridges of the saw-teeth run with the length of the building, water can be most conveniently removed from the valleys by conductors placed at intervals of 40 to 60 ft. apart in the valleys. Experience in New England seems to show that a 3-in. conductor so placed is amply sufficient to take care of 1,000 to 1,200 sq. ft. of roof surface, providing the conductor has a free downward run of 12 or 15 ft. A slight pitch of the bottom of the valley toward the conductor opening in the roof, is easily effected by furring up the roof under the roof covering. In a roof recently built from Mr. Richmond's design, a pitch of 3 in. in 20 ft. proved amply sufficient to remove all the water from the bottoms of the valleys. The conductors after coming through the roof can be connected into a larger pipe near the roof, or be carried down through the room, and be disposed of in the basement. The strainer on the roof often fits into a roof thimble made tight with the roof covering, and the thimble runs down into the conductor pipe proper. The connection of the roof thimble with the top of the conductor is frequently a slip joint, made by slipping the thimble some 12 in. down into the conductor, and when the pipe connecting the conductors is near the ceiling, and only slightly pitched, there is danger in very heavy rains of its filling, and of the water backing up and overflowing between the roof thimble and the top of the conductor, unless the connecting pipe is made of very ample proportions. It is better to carry the conductors down to and through the floor and gain the effect of the head in the vertical pipe to rapidly discharge the water.

The amount and diffusion of light can be made almost perfect for the most exacting requirements, and this is the pre-eminent advantage of saw-tooth lighting. By no means a small economy in the use of saw-tooth roofs is the saving in time during which artificial light is needed, as compared with side-lighted rooms in factories of usual proportions. One textile mill in which a saw-tooth lighted building of very large area is near a several storied building about 90 ft.

wide, the same processes being followed in both buildings, reports that lights are lit an hour earlier in the storied building than in the saw-tooth building. As the lighting frequently runs up into the hundreds of horse-power, the saving is material. It is frequently reported that a greater production of the same class of goods is obtained from saw-tooth lighted rooms, than from side-lighted rooms, with identical machinery running at the same speed in each, and it is somewhat hard to believe that the difference exists. The explanation seems to be primarily in the almost perfect light, and from the fact that a better class of help is attracted and retained for the very reason that the light and working conditions are better. In one case at least the advantage of the saw-tooth lighted building is distinctly measured by the lower piece price paid for weavers in the saw-tooth building as against the piece price paid weavers on the same class of work in the neighboring side-lighted building. The difference is stated to be ten per cent.

The cost is undoubtedly greater for a saw-tooth roof, than for a flat or other plane roof. The actual amount of roof is almost as great ordinarily in the saw-tooth form as in the plane form, and may be more, and in addition there is more framing, all the windows with their trimming, all the flashing below the windows and in the internal gutters, a large amount of painting, frequently a larger cost for conducting water from the roof, and a larger cost for the heating and sprinkling, as compared with plane roofs. These items may increase the cost of a saw-tooth roof from 40 per cent. to 60 per cent. over a plane flat roof without skylights, but this can hardly be considered a fair measure, as to obtain results fairly comparable with properly designed saw-tooth lighting, the engineer must consider the whole cost of side lighted buildings of sufficient height in the stories and sufficiently limited in width to give satisfactory light, and should also consider the whole cost of the saw-tooth lighted building. Where the work or process requires large amounts of nearly perfect light, or is bettered or done at less cost by having it, the final balance of advantage seems to incline strongly toward the saw-tooth form.

The proper proportioning of the saw-tooth light is important to obtain the best results without wasting money in their erection. Some saw-tooth roofs have been designed with the span of the saw-tooth very short relative to the height, thus making the backs of the saw-teeth very steep, and the valleys sharp and narrow. The result seems to be some loss of light, on account of the obstruction formed by the backs of the saw-teeth themselves, and there is an unnecessary expense for glass and flashings, as fewer saw-teeth with longer spans or the same number of saw-teeth with shorter windows would give all the light needed. The opinion of Mr. Richmond, after an examination of the lighting effect in a very considerable number of saw-tooth lighted rooms, designed by different engineers, is that to obtain the best results, there should be no intervals between the saw-teeth. A flat place on the roof generally means a shadow, even if slight, or perhaps only a less brightly lighted area, and makes a break in the otherwise almost perfect diffusion of the light. By the same reasoning the obstruction caused by the necessary space and flashings below the windows and by the supporting girders carrying the saw-tooth frames should be kept at a minimum. With attention paid to these points, a proportion of height of window to length of span of the saw-tooth, in the ratio of 1 to 3½ or 4, gives all the light desirable in this climate, and if this ratio is exceeded it is at the expense of greater first cost for glass, and a greater running cost for heating, although special conditions may make the proportions unsuited to a given case.

Refuse Disposal in the Borough of Richmond, New York.

The authorities of the Borough of Richmond, of New York City, have recenty made public plans and specifications for a mixed refuse destructor which are the result of about two years' study and investigation. The work has been under the general direction of Mr. L. L. Tribus, M. Am. Soc. C.E., commissioner of public works, and in the personal charge of Mr. J. F. Fetherston, Assoc. M. Am. Soc. C.E., superintendent of street cleaning. It involved a determination of a method of final disposition suited to the local conditions, based on careful records of the different classes of refuse and investigations of the calorific power of the combustible materials, and affords a model of procedure to other places where this problem is important.

The closely inhabited section of the borough is divided into two refuse collection districts, each about four miles long by two miles wide, and containing in all approximately 60,000 people. In the West New Brighton district garbage is burned in a Dixon crematory. In the Stapleton district refuse is mixed and used for filling low lands. Dumping places were sources of nuisance, and the haul from centers of collection to places of disposal increased year by year. Destruction by fire of decomposable refuse was the only practical means available because of the location, population and topography of the districts under consideration. In 1903 a plan for refuse removal from central storage stations to an outlying crematory was devised, but the street railway company failed to agree with the borough authorities upon a rate of transportation, and after various inquiries, examinations and studies no existing garbage crematory was found which was held to satisfy the conditions of sanitary and economical final disposition. Thus a radical change in former methods became necessary.

After a study of available technical publications, it appeared that the British method of destroying mixed wastes offered hopes of solving the problem, provided the refuse materials were self-combustible, upon which point there was much doubt. In May, 1904, work was started with the object of obtaining definite information concerning the following subjects: 1. The quantity of refuse contributed per capita per annum by volume and by weight. 2. The seasonal variations in quantity of refuse by volume and by weight. 3. The components of refuse and their seasonal variations. 4. The calorific power of refuse. 5. Practical tests in burning local mixed household refuse by means of forced draught. It was believed that by determining the foregoing factors a method might be devised for dealing with the refuse of the borough, should mixed refuse destruction prove unsuitable. As a result, however, of the various tests, recommendation was made in December, 1904, for the erection of two furnaces of the British type, one for each refuse collection district.

Pending the acquisition of property for the erection of the first installation serving the West New Brighton district, 39 destructors in Great Britain and one in Canada were visited by Mr. Fetherston, and the experience thus gained resulted in requesting proposals for a type of destructor which is expected to meet the conditions of the West New Brighton district in a sanitary and economical manner.

The Greater New York Charter requires that for all patented articles competition shall be secured, and as the various modern destructors differ in dimensions and features of design, it was necessary to provide some general basis upon which bids could be secured. At the same time, it was felt that untried or experimental furnaces should not be given consideration, and requirements were introduced in the specifications and contract which made it necessary for contractors to present evidence of previous successful experience in dealing with mixed household refuse.

The average amount of ashes and rubbish collected in the district is 2.77 cu. yd., or 1.164 short ton per 1,000 inhabitants per day. These materials range from about 85 per cent. of the total refuse during the winter to about 50 per cent. in the late summer. Under ashes are included the ashes from stoves and furnaces, glass, crockery, dirt, stones and other inorganic matter, while rubbish includes wood, paper, rags, excelsior, straw, leather, rubber and like materials. The average amount of garbage is 0.91 cu. yd., or .0425 ton daily, per 1,000 people; the amount ranges from less than 15 per cent. of the total refuse material during the winter to about 50 per cent. in the late summer. Taking the entire refuse for the year, it has been found that 34.7 per cent. by weight was fine ash passing a ⅜-in. screen, 1.8 per cent. was clinker that could be picked out of the ashes and rubbish by hand, 4.8 per cent. was glass and metals, 26.7 per cent. was coal and cinders and consisted of material rejected by the screen and not otherwise classed, 22.6 per cent. was vegetable garbage, 1.2 per cent. was animal garbage, 1.1 per cent. was free water lost in handling the garbage, and 7.1 per cent. was rubbish.

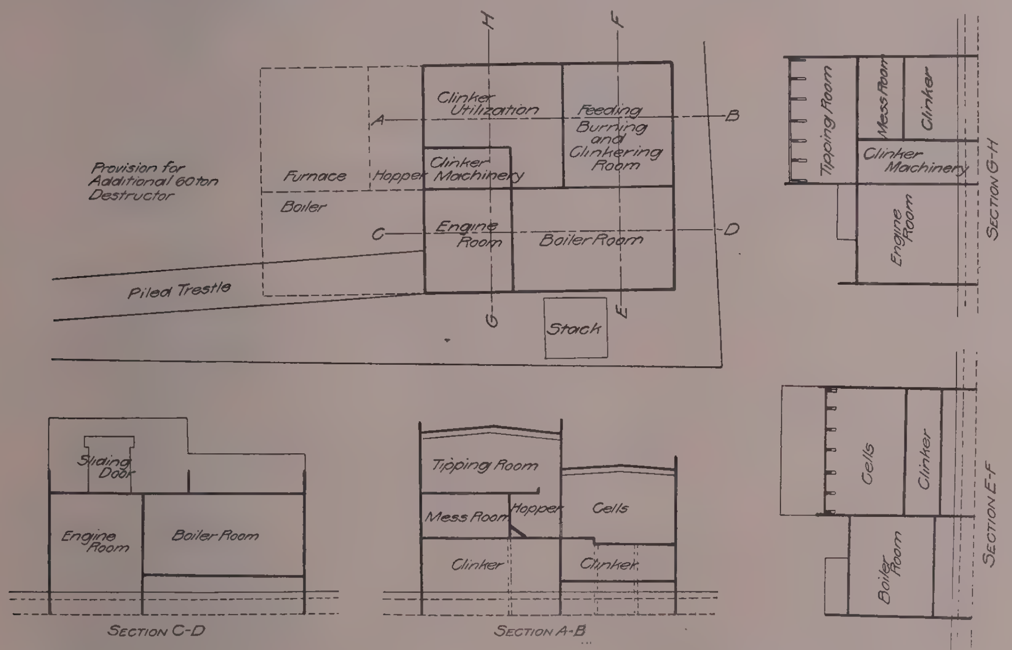
The calorific value of these materials was determined by a number of calorimeter tests made in the Lederle Laboratories. The coal and cinders were found to average 4,900 B.t.u., the garbage 8,240 B.t.u. after drying, the rubbish 8,440 B.t.u., while the fine ash and clinker had no calorific power. As the calorific tests were made on materials containing very little moisture and as garbage consists mainly of water, a series of evaporative tests were carried out which showed that there was from 67 to 75 per cent. of water in the garbage.

The destructor buildings, runway, connecting flues and chimney will be constructed of reinforced concrete, and will not be designed until the contractor for the destructor has furnished plans which will enable the former structures to be detailed properly. The destructor must be capable of burning 120,000 lb. of mixed refuse of the general composition that occurs in winter, and under normal working conditions. Provision must be made for a future doubling of the capacity of the plant.

The general arrangement suggested, but not insisted upon, for the plant is shown in the accompanying diagrams. The layout provides for tipping the refuse behind closed doors into a storage hopper capable of holding 120 cu. yd., or 60 tons of refuse. It will be shoveled from the hopper directly into the cells, clinkering at the front and dropping the hot clinker through the floor to a lower level. It is proposed to use the heat abstracted from the clinker in raising the temperature of the air required for combustion, if practicable, otherwise the clinker hopper will also serve as a storage and cooling chamber. The products of combustion pass to a water-tube boiler, placed at a lower level than the cells, and thence to the stack. Space is left for engine and clinker machinery rooms, but it is not proposed to purchase any machinery until the amount of power available is determined by actual operation. For the same reason, it is proposed to blow off the steam until the best method of utilizing it can be ascertained. The idea governing the arrangement indicated in the diagram is to provide as much light, air and room as possible for the comfort and convenience of the men.

It is suggested, although not required, that the air for combustion be drawn through ducts from the upper portions of the cell and tipping rooms, thus controlling the flow of dust and smoke and causing air to flow into the building rather than dust and smoke to escape. It is also suggested that a chamber might be arranged so that dead animals could be lowered through a port on the boiler room deck into a combustion chamber. The plant is to be run continuously weekdays and cleaned on Sundays. Among the appurtenances required of the contractor are draft gauges for recording ash-pit pressures, self-recording steam gauges, high-temperature indicators, a continuous CO_2 recorder of the gravimetric type, low-water indicators for the boiler, thermometers for recording stack and other temperatures, a chimney-draft gauge, and the usual boiler accessories.

The guarantees required are as follows: 1. The residue from the furnace under ordinary conditions of operation shall be free from organic matter, thoroughly burned, hard and vitreous. 2. No nuisance shall be created in the ordinary operation of the plant. 3. Neither odors, obnoxious gases nor dust shall escape from the building or chimney. 4. At no time during the continuous operation of the plant shall the temperature of the combustion chamber or main flue fall below 1,250° Fahr. 5. The flues, dust chambers and boiler settings shall be so arranged that the dust may be withdrawn after one day's cooling of the fires. 6. A minimum or a seasonal rate of evaporation from and at 212° Fahr. shall be guaranteed, and also an amount of net useful steam per pound of refuse burned. 7. The amount of material that can be handled during an 8-hour shift by a high-grade stoker must be stated. 8. The refuse must be destroyed at the rate of 2½ tons per hour when its character is that shown by the data of winter collections, to which reference has already been made.



Proposed Arrangement of Refuse Destructor Building, Borough of Richmond.

Automatic Adjustment of Pressure and Volume of air delivered is a peculiar function of the fan blower. Instead of always delivering a constant volume regardless of influencing conditions, it will increase the volume of delivery as the resistance to the flow is decreased. If, on the other hand, a blower has been operated with a free outlet opening of area in excess of its capacity and the free area of the outlet be then decreased, the pressure of the fan's delivery will immediately rise, tending to overcome the increased resistance. As a result of this, if a certain maximum pressure is known to be required a fan may be speeded up to give it at such times as the conditions demand, while at other times, when less pressure or volume of air is required, proper manipulation of the blast gate will economize power.

Allowable Pressures on Deep Foundations.

Data on allowable pressures on deep foundations recently collected and analyzed by Mr. E. L. Corthell show that the pressure of stable structures on the material on which they are founded ranges between the following limits: On fine sand, between 4,500 and 11,600 lb. per sq. ft., averaging 9,000 lb. in ten examples. On coarse sand and gravel, between 4,800 and 15,500 lb., averaging 10,200 lb. in 33 examples. On sand and clay, between 5,000 and 17,000 lb., averaging 9,800 lb. per sq. ft. in 10 examples. On alluvium and silt, between 3,000 and 12,400 lb., averaging 5,800 lb. in 7 examples. On hard clay, between 4,000 and 16,000 lb., averaging 10,160 lb. in 16 examples. On hard pan, between 6,000 and 24,000 lb., averaging 17,400 lb. in 5 examples. These cases show no settlement. Besides the foregoing cases three instances were found in which notable settlement took place in fine sand, with a minimum load of 3,600 lb., a maximum load of 14,000 lb. and an average load of 10,400 lb. In clay, principally London clay, in 5 examples the pressure ranged between 9,000 and 11,200 lb., averaging 10,400 lb. In silt and alluvium two cases of settlement were reported, with loads of 3,200 lb. and 15,200 lb., a wide variation. Three cases of failure on a mixture of sand and clay are given, the pressures ranging between 3,200 and 14,800 lb., averaging 6,600 lb. This should be compared with the average of 9,800 lb., and range of 5,000 to 17,000 lb., in 10 examples, already referred to, in which no settlement occurred.

Electric Drainage Pumps are used in the vicinity of Altona, Holland, for keeping down the water in about 11,400 acres of marsh. The central station has a rated capacity of 260 kw., furnished by two units arranged for parallel operation. Each unit has a horizontal tandem-compound engine and a three-phase generator furnishing current at 3,000 volts. There are four Lancashire boilers, one as reserve, which furnish steam at 150 lb. From the station current is delivered to 21 motor-driven pumps, located at the most advantageous drainage points in the marsh. The drainage areas served vary from 25 to 4,200 acres and the lifts from 4.3 to 6.6 ft., thus requiring power in widely varying amounts. It would have been too costly to proportion each pumping equipment to the work actually to be performed, and accordingly six standard sizes of motors of 2, 5, 11, 23, 46 and 100 h.-p., respectively, were employed.

A Remarkable Experience with Pond Water.

In August of last year there was a sudden destruction of the fish in Weequahic Lake, in the Newark, N. J., park system; no explanation of it which the local authorities could suggest was satisfactory to them, and so they requested Messrs. Herbert B. Baldwin, of Newark, and George C. Whipple, of New York to investigate the matter. This was done and showed in a striking manner the close relation between the carbonic acid and dissolved oxygen in water and the growth of microscopic organisms. The occurrence was so unusual and its lessons so instructive that a full account of it was prepared by the gentlemen named for the recent convention of the American Public Health Association, from which the following notes were taken.

The lake has a drainage area of approximately one square mile and its water surface is about 30 acres. Its average depth is between 5 and 6 ft., but it is said that there are certain places where the depth is 10 or 12 ft. The site of the reservoir before construction was a swamp, in which the mud and peaty material varied in depth from 2 to 10 ft. Nearly half of its area was covered with a heavy growth of cat-tails. The peat and mud were not removed from the reservoir bottom at the time when the dam was built, but since then masses of peat, alder roots, old stumps and cat-tails have been taken out as they have floated to the surface. Although great quantities of such matter have been removed, much remains.

It is said that there are numerous springs at the bottom of the lake. Measurements have been made of the run-off, which have shown that the average discharge is about 1.5 million gallons per day, a high figure for a watershed of only one square mile, and indicating a considerable influx of ground water. There are two inflowing brooks; one of these, a small one, flows through a cemetery; the other flows through a bog hole.

It is said that during the last two years floating microscopic algae (the so-called plankton) have been present in large numbers during the summer—in other words, the lake has shown the phenomenon of purging, or blooming. The algae growths have generally started in July and continued well into September.

Some time during one Sunday night in August of last year, large numbers of fish died in the lake. When the attendants left the reservation on Sunday afternoon no dead fish were noticed around the shores; but on Monday morning they were found in great quantities. They continued to die during the day and also during Monday night. It has been estimated that in all upwards of 120,000 fish, or more than fifteen tons, died during these two days, including bass, roach, sunfish, catfish, suckers, eels and a few carp. They varied in size from sunfish only two inches long to black bass weighing from 5 to 6 lb., while one carp weighed nearly 20 lb.

The dead fish were found in all parts of the lake. On Monday it was noticed that they were especially numerous near the two inflowing brooks. Instinct had apparently led them to seek the water entering the lake. Some of the eels even left the lake and traveled up one of the brooks for a considerable distance. Near the center of the lake there is a spring, and it was said that fish in the vicinity of this spring were found to be living and were more lively than some of the living fish found elsewhere.

The cause of this destruction of the fish was the sudden exhaustion of oxygen in the water on Sunday, which was probably due to the decay of the algae. The fish apparently died by suffocation. On Monday it was noticed that many of the fish were gulping air at the surface of the water, and it was observed that very many of the fish died with their mouths open, a phenomenon which has been observed before when fish have died from this cause. Examination of specimens of fish by Mr. G. H. Townsend, director of the New York Aquarium, showed that they were in a normal condition, as would be the case if they died from lack of air. The fact that many fish sought the incoming waters, which were well aerated, is also an evidence that oxygen was lacking in the water of the lake.

Messrs. Baldwin and Whipple began their observations on Tuesday, after the dying of the fish had practically ceased. Near the south end of the lake it was found that at the surface the water was only half saturated with oxygen. At a depth of 1 ft. the amount was only one-third of that required to saturate it, while below that depth the oxygen was practically absent. At the north end of the lake the surface water contained 79 per cent. of oxygen required to saturate it, while at a depth of 3 ft. it contained 3 per cent. In other words, below a depth of 1 or 2 ft. the water of the lake was practically devoid of oxygen.

That the exhaustion of oxygen was due largely to the decay of algae seems certain. During Sunday it was remarked by the attendants at the park that the color of the water was changing from green to a yellowish brown, and that as night came on the water became clearer than it had been. Experience with algae growth leads Messrs. Baldwin and Whipple to believe that these changes were due to the death of the algae and their settlement to the bottom of the lake. At the bottom of the lake the algae decomposed, as was evidenced by innumerable bubbles of gas which were seen rising through the water on Monday and Tuesday. This phenomenon was noticed on Monday when the dead fish were first seen, and it was still strongly marked on Tuesday afternoon. It seems likely that decomposition of the muck at the bottom of the lake also contributed to the exhaustion of oxygen. Furthermore, the oxygen being exhausted at the bottom allowed putrefaction to set in, the conditions being somewhat analogous to what goes on in a septic tank of a sewage disposal system. Decomposition occurred to such an extent at the south end of the lake that great masses of roots and peat floated to the surface and drifted around as miniature islands, and on disturbing them with a pole large volumes of gas were liberated.

That water entirely devoid of oxygen will not support fish life is well known, and that slight reductions in the amount of oxygen below the point of saturation do not materially affect fish life is also known; but the absolute amount of oxygen necessary for the life of various kinds of fish is not known with certainty.

Some experiments have been made in this connection by those interested in methods of sewage disposal. The ability of fish to live in sewage effluents has been frequently used as a test of satisfactory oxygenation. In Clowes' work on "Experimental Bacterial Treatment of London Sewage," it is stated that "sewage effluents that contained 38 per cent. of the amount of oxygen required for saturation were capable of sustaining the life of goldfish indefinitely, while in these same effluents less hardy fish, such as roach, dace and perch, became sickly after living in the effluent for a week or so." In Dibdin's "Purification of Sewage and Water" reference is made to a prolonged series of experiments on the Thames River water, which showed that when the percentage of saturation fell below 50 per cent. there was little chance of fish thriving in the water, and that when it fell below 30 per cent. no fish could sustain life for any prolonged period. In Dr. Bruno Hofer's "Handbuch der Fischkrankheiten," there are given some figures based on experiments, the substance of which is as follows: Salmonoid fishes die if the oxygen content of water falls to 1.5 c. c. per liter (this is equivalent to 24 per cent. of saturation at 20° C., or to 19 per cent. at 10° C.); cyprinoid fishes, such as carp, goldfish, roach, etc., succumb when the oxygen content falls to 0.5 c. c. per liter. Fishes cannot utilize the last remnants of oxygen present in the water. In winter when metabolism is reduced, salmonoids require 3 and 4 c. c. per liter (35 to 45 per cent. of saturation at 5° C.). Experiments which have been made by the United States Bureau of Fishes have shown that black bass and yellow perch died in fresh sewage within seventeen hours, the oxygen content being about 1 c. c. per liter, while the same sewage when artificially aerated was harmless.

In order to get back to the primary cause of the death of the fish it remains to be ascertained what caused the sudden decomposition of the algae on Sunday; and this is a matter of speculation, but unquestionably several factors worked together to produce the sudden death of the algae. Of these the meteorological conditions which existed for a number of days before the phenomenon took place must have been very important. The weather had been extremely warm and the temperature of the water must have become very high at the surface. On Tuesday the temperature of the surface water was 82°. In all probability it had been higher on preceding days, as the weather had been hot and the humidity high enough to prevent evaporation from the surface. There had been but little wind, and for a number of days previous the surface of the lake had preserved a mirror-like calmness. Under these conditions the lake water became temporarily stratified, with the warmer water at the top. During such quiet weather algae tend to rise to the surface and form a scum. Becoming concentrated near the surface the tendency would be for their food material to become exhausted, while the high temperature itself would be prejudicial to their growth.

Another fact worth mentioning was the almost complete absence of aquatic plants from the lake. No water-weeds or eel grass, or even filamentous algae were to be found anywhere along the shores. On the other hand, the result of the fish fatality showed that the lake must have been to a very considerable extent overstocked with animal life. In other words, there was no equilibrium between the animal and plant life in the lake. Speaking generally, animal life makes a heavy drain on the oxygen contents of a natural body of water; plant life tends to restore it. Certain kinds of algae, namely, those which contain chlorophyl, are powerful oxygenators. There is some reason to believe that the blue-green algae are not as vigorous oxygenators as those algae which have green chlorophyl instead of the blue-green modification of it. At any rate it has been noticed for many years that oxygen has been deficient in reservoirs where those organisms have predominated.

Algae require carbonic acid. In such a lake as that in the Weequahic reservation this is derived very largely from the decay of carbonaceous material at the bottom. When the water is in a state of circulation this carbonic acid manufactured by the bacteria at the bottom of the lake is distributed through the water, furnishing food to the algae. Stratification would tend to cut off the supply of carbonic acid from those organisms which were at or near the surface. Some algae appear to have some power to seize carbonic acid from the bicarbonates in the water, but there is a limit to which this can be done.

The return to normal conditions occurred even sooner than was anticipated. On Wednesday a breeze sprang up which ruffled the surface of the lake at one end considerably. This led to a restoration of the oxygen in the upper layers of the water. Two days later the wind further increased and resulted in the more complete oxidation of the water, especially at the end of the lake towards which the wind was blowing. Following the decay of Anabaena and Clathrocystis other organisms began to make their appearance in large numbers, which contain chlorophyl and are strong oxygenators. They developed with such rapidity that the oxygen in the water was increased beyond its points of saturation. The amount of oxygen which water will hold in solution in contact with atmospheric air depends upon its temperature, being nearly double as much in winter as it is in summer. For such temperature there is a certain amount of oxygen which will just saturate water. This is termed a saturation of 100 per cent. If an analysis shows the presence of a smaller or larger amount than this, it is common to express the result in terms of the percentage of saturation. Percentages higher than 100 are frequently observed in nature. In some cases they are due to the pressure of free oxygen liberated by growing plants.

A surcharging of the water with oxygen was first noticed on August 22. At one point in the lake the water at the surface contained 149 per cent. of that required to saturate it, while the water at a depth of 1 ft. contained 110 per cent. Below a depth of 2 ft. oxygen was deficient. At another point on the same date the surface water contained 179 per cent. of that required to saturate it, while below a depth of 2 ft. the conditions were about the same as at the other end of the lake, the percentages of saturation being low. The temperature observations on this date pointed to a marked stratification of the water.

On August 24 the stratification of the water had almost disappeared. This was shown by the fact that there was but little difference in the temperature of the water at the top and bottom, and also by the fact that the differences between the oxygen figures at the top and bottom were less. It was noticed that wherever the temperature difference was considerable the difference in the oxygen contents was also great.

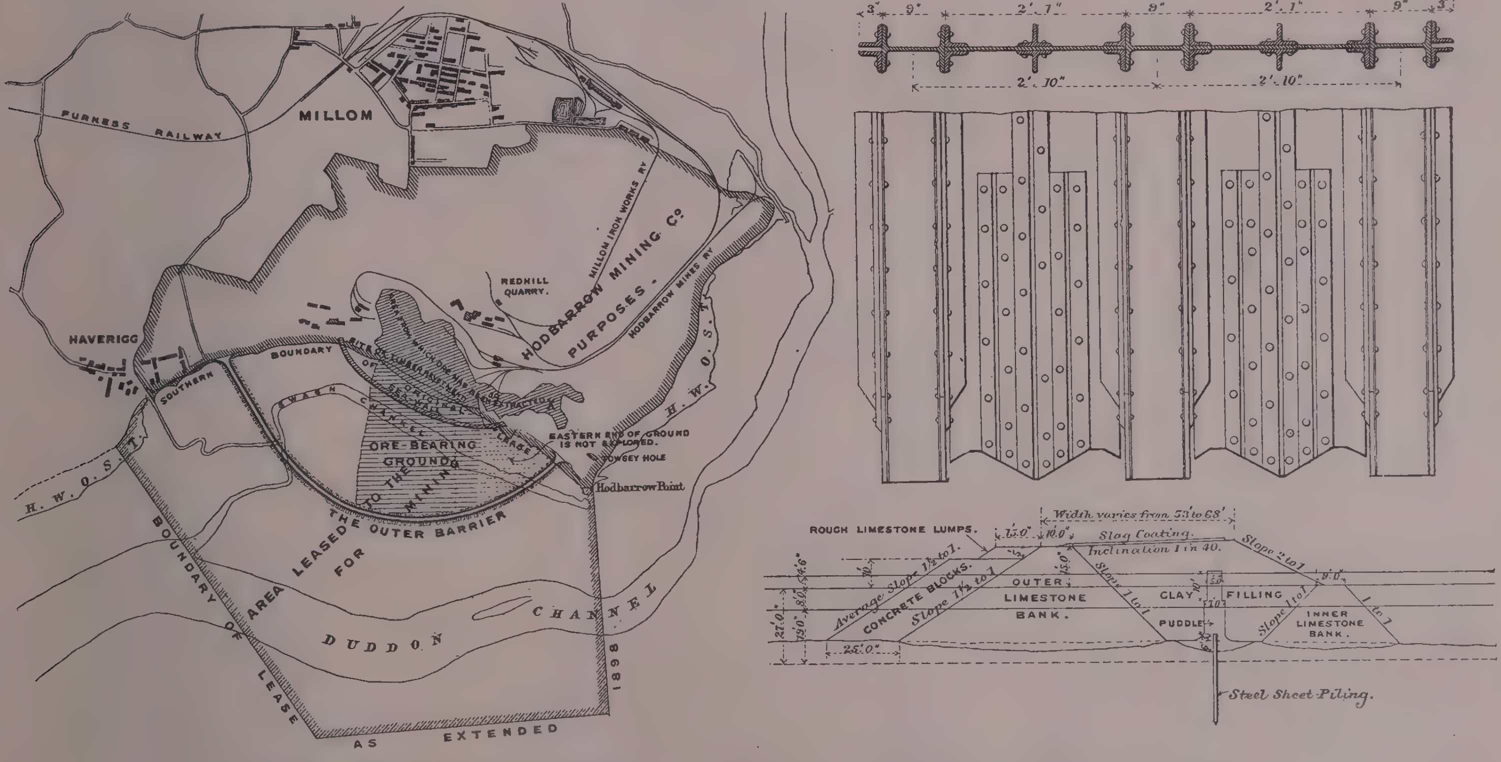
As a result of the mixture of the water on August 24 through the action of the wind, the surface water ceased to be surcharged, while the oxygen contents in the lower strata increased. These same conditions were observed on subsequent dates, and in general it was found to be true that whenever the water became stratified the surface layers became surcharged with oxygen, while after a mixing up of the water there was an increase in the amount of oxygen at the bottom, due to a distribution through the vertical of the excess oxygen from the surface.

Tests of the water for free carbonic acid showed that, in general, the amount varied inversely with the amount of oxygen present. On those dates when the water was stratified and when the surface water was saturated with oxygen, the amounts of carbonic acid were low at the surface and high at the bottom. Apparently during the stagnant periods the water in the lower layers acquired carbonic acid, while the water in the upper layers acquired oxygen. When the waters became mixed up, through the action of the wind, there was a consequential evening up of both the oxygen and carbonic acid throughout the vertical.

It was not thought possible that the atmosphere could be responsible for the superabundance of oxygen at the surface, inasmuch as this occurred at times when the water was stratified rather than when the surface of the lake was ruffled by the wind. It was noticed that with the return of the oxygen to the water, after the decay of the blue-green algae, other microscopic organisms increased in amount as already mentioned. As these organisms contain chlorophyl they were naturally looked to as the source of excess of oxygen.

The Outer Sea Barrier at the Hodbarrow Iron Mines.

The outer barrier built at the Hodbarrow Iron Mines at Millom, Cumberland, England, in order to enable a large amount of valuable submerged iron ore land to be worked, was briefly described in this journal on May 13, 1905. The work is not only interesting in itself but also on account of its purpose. The southernmost part of Cumberland is Hodbarrow Point, a limestone promontory rising to a height of 50 ft. above the Irish Sea on one side and the estuary of Duddon River on the other hand. Valuable veins of ore were found in the limestone on the water front, and were worked backward, inland, fifty years or more ago, until they pinched out. Since then there has been a struggle to extend the workings seaward, and the outer barrier is the last step in the process of reclamation. An elaborate paper concerning it, written by Mr. H. S. Bidwell, resident engineer, was recently published by the Institution of Civil Engineers, from which the following notes have been prepared.



The Outer Barrier of the Hodbarrow Iron Mines, for Reclaiming Submerged Ore Lands.

When the land veins first mined were exhausted, mineral rights were given to the Hodbarrow Mining Co., under which it made some explorations and carried on operations. After working for a considerable time, a new body of ore was discovered, extending seaward, from which an average 450,000 tons of red hematite has been taken annually since 1873. The bed grades upward toward the shore and has a clay cover on land, but under water there is a bed of limestone between the clay and ore. The clay cover is topped in turn with irregular strata of sand, gravel and clay. Sand and water occasionally poured into the workings from these strata and accordingly a timber revetment was constructed along the shore to keep back the sea. This structure was breached during a heavy gale and exceptionally high tide. The company's mineral rights extended only to the high-water mark on the shore, and it was manifestly impracticable to work up to that line on account of the danger from the sea. Accordingly a heavy seawall was built twenty years ago under the direction of the late Sir John Coode. It was a rigid structure of concrete, backed by a clay embankment and made water-tight by a wall and trench of puddled clay immediately behind the concrete wall and keyed into the underlying clay bed. Six years ago a bed of quicksand was tapped in the mine, which established a connection between the sea and the underground workings. A heavy rush of tidal water into the mine occurred, and before it could be checked by filling the cavity on the foreshore with brush and clay, the seawall showed signs of distress. The clay backing of the concrete settled about 5 ft. and in this way the connection with the sea was shut off. The damaged portion of the wall was protected from the sea by a wave breaker of 20-ton blocks of concrete dropped at random, and the embankment raised and widened.

Meanwhile a lease of the foreshore property had been obtained, and Messrs. Coode, Son & Matthews were retained to design an outer barrier to exclude the sea from this extended area of 170 acres. The whole of this ground is not ore-bearing, but it was necessary to include a certain portion of barren ground in order that the barrier should be located a considerable distance outside the treacherous ground in which subsidence had taken place.

In the design of the barrier the primary objects kept in view were, first, that the structure should be flexible instead of, as in the case of the first sea-wall, rigid, in order that, should subsidence take place beneath it at any time, the barrier itself should also subside, and thus close any cavity that might be formed, when, by adding material to the superstructure, its efficiency as a protection to the mines would be maintained; and, second, that it should be of great weight, in order to compress the upper stratum of sand on the foreshore and thus aid in preventing percolation beneath it, and also to secure its subsiding if necessary. A further consideration to which prominence was given was that, as far as possible, material obtainable in close proximity to the work should be utilized in its construction.

It is 6,870 ft. in length, and consists primarily of a main outer bank of limestone, an inner bank which it was originally intended to construct of iron slag, but which was largely composed also of limestone, and a filling of clay between these two banks. As a protection against heavy waves the outer limestone bank is provided, for 1,600 ft. from the shore at each end, with a coating of large lumps of rough limestone weighing up to 15 tons. Seaward of this the protective coating is formed of 25-ton concrete blocks deposited irregularly.

Beneath the surface of the foreshore, under the center of the clay embankment, a water-tight cut-off is provided, and for this three methods were adopted: first, where the natural clay bed was near the surface the cut-off was formed by a trench of puddled clay, carried down and well keyed into the clay bed; second, where the clay bed existed, but was at too great a depth to be reached by means of trenching, pitch-pine sheet-piling, grooved and tongued, was driven down into the clay; and, third, where no clay was found, or where the bed was so irregular as to be unreliable, steel sheet-piling, of lengths varying according to circumstances, was driven. In order to guard against the passage of water through the barrier, a wall of puddled clay is constructed in the heart of the clay embankment, immediately above the puddled trench or the piling, as the case may be. It is brought up to 5 ft. above high water of ordinary spring-tides, which is 6 in. above the highest recorded tide, a level that has been reached only once, and approached but seldom, in a large number of years.

For the purpose of discharging water which might accumulate in the reclaimed area, four sluice-ways are provided, having penstocks worked from the road-level of the barrier and tide-flaps at the seaward ends.

The order of construction was as follows: The formation of the water-tight cut-off below foreshore-level was first begun, followed by the main limestone bank and the inner bank; the latter was kept slightly behind the former with a view to shelter, while the filling for the clay portion of the embankment was deposited after such an interval as would permit of the formation of the lower portion of the puddle wall as described later.

A beginning was made with the puddled trench at the west end, but the work of excavating had not proceeded very far when it was decided that the attempt to carry out this portion of the work in puddled trench should be abandoned, and that pitch-pine sheet-piling should be substituted.

At the east end the puddled trench was carried out for a length of 1,040 ft. from the shore. The first 200 ft. was carried down to rock, into which it was keyed to a depth of 2 ft., the recess being excavated by blasting with light charges of dynamite to receive the footing of the puddle. Beyond this point, for a distance of 180 ft., clay appeared on the surface; but on excavating in this clay to carry the puddle into it to the specified depth of 1 ft. 6 in. it was found not only that the clay was of an unsatisfactory character but also that it was underlaid by a water-bearing stratum of gravel. The trench was therefore carried down through this water-bearing stratum and keyed into the rock or solid clay which was found beneath. From this point outwards the trench was taken down through sand and gravel to the clay bed, which was reached at a depth varying between 2 ft. and 13 ft. The trench was generally 7 ft. wide, and where the depth necessitated the use of an inner setting of the timber runners, by means of which it was sunk, this inner setting had a minimum width of 6 ft.

When the work had proceeded for some time, the clay bed at this east end began to be very irregular, sometimes dipping almost vertically both in the line of and transversely to the work. Thus, in the width of the trench, 7 ft., there would be a difference of level of as much as 4 ft. in the surface of the clay. It was therefore seen that, even if conditions became no worse, it was very doubtful whether a satisfactory cut-off could be made by the proposed method, and a series of borings was commenced at close intervals between the then existing end of the puddled trench and the point at which it had been proposed to terminate the 31½ ft. steel piling.

Having regard to the information disclosed by these borings, it was decided to discard the puddled trench and substitute for it steel sheet-piling. It was now considered advisable that the borings should be continued along the remaining section of the work where it had been intended to form the cut-off by puddled trench, and this was accordingly done. From them it was apprehended that the puddled trench might not prove satisfactory here, in view of the curious lateral irregularities which had previously been met, and it was determined that here also it should be superseded by steel piling.

The timber sheet piles were whole timbers, not less than 12x12 in., grooved and tongued. For the first 150 ft. of the work the piles were 18 ft. in length, and thence onwards they varied between 23 and 27 ft., according to the depth of the clay, into which they were to be driven 4 ft. The piling was driven in bays of 10 ft. each, that is to say, the gauge-piles were spaced 10 ft. apart between centers, and they were driven 2½ ft. deeper than the sheet-piles. A series of gauge-piles was first driven by one piling-engine: a second engine then followed, and drove the eight sheet-piles in each bay, also completing the bay by driving the central key-pile. The grooves in the piles were 3¾ in. wide and 1⅞ in. deep, and the tongues 3½x3½ in., the latter being secured to the piles by 10-in. spikes driven 18 in. apart. When driven to the requisite depth, the heads of these piles stood 3 ft. above the ground-level, and at 1 ft. from the top a 12x6 in. waling was fixed on the landward side of the sheeting, being secured to each pile by a 1⅛-in. bolt.

Where obstructions were met, a shaft was sunk and the obstruction was removed, or if necessary the pile was drawn and started afresh. In two places neither of these courses was feasible, and here a boxing of piles was driven on the seaward side of the cut-off to enclose the defective part, the enclosure being subsequently filled with puddled clay.

The piles having been driven, as each two or three bays were completed the sand on either side of the sheeting, between the outer and inner stone banks, was excavated to form a basin-shaped hollow 4 ft. deep at the piling and 34 ft. in width where the distance between the two banks would admit of this. The hollow, having been cleared of weeds, mud, etc., was filled with puddled clay, thus providing a flap which should prevent the creeping of water at the upper portion of the sheeting and form the foundation of the puddle wall.

When the first length of 1,200 ft. of this timber sheet-piling had been driven, the succeeding section of steel piling was proceeded with and completed, and a beginning was made with the second series of timber piling. The ground through which the latter portion of the steel piling had been driven had proved exceedingly hard, and conditions became no more favorable when the timber piling was proceeded with. Pile after pile refused to be driven, and showed obvious signs of being crippled. It was considered impossible to ensure that timber piling would successfully penetrate the bed of hard gravel and stones and make a satisfactory junction with the clay; and it was decided that this piling should, like the puddled trench, be superseded by steel piling. The whole remaining portion of the cut-off was therefore executed in steel piling, forming, with the section already driven, a continuous diaphragm ⅞ mile in length.

The original system of steel piling consisted of gauge piles driven 11 ft. apart on centers, with four sheet piles and a central key pile between them. The gauge piles were 9x7-in. I beams, with a pair of angles riveted on the outside of each flange to form a slot. The sheet piles were ¾-in. steel plates 2 ft. wide, stiffened near one edge with a pair of 3x¾-in. bars, leaving the plate projecting as a tongue, and provided on the other edge with a pair of wider bars which projected to form a groove. A bay of this piling was driven experimentally, but it was found to tear apart and bend so badly that the designs had to be revised. After further trial the type shown in the illustration was adopted.

In sinking the steel sheeting, short timber piles were first driven to carry an engine platform and the appliance for keeping the line of piling true. These timber piles were on 10-ft. centers along the line of the works. The two front rows were respectively 1 ft. 4 in. in front of and behind the line of the sheeting, and to them were fixed 12x12-in. walings, the space left between these being thus 8 in. These walings were placed so that their upper side was 1 ft. 9 in. below the finished level of the top of the steel piling. Between these walings, and secured to them by coach-screws, were fixed distance-blocks, the space between these being exactly that occupied by a gauge-pile, while their width allowed a clearance of 2 ft. 1⅛ in. between the flanges of the gauge-piles, the sheet-piles being 2 ft. 1 in. wide. These blocks had rubbing-pieces of ¼-in. iron plate at each side, to take the edges of the angle-jaws of the gauge-pile. A considerable length of staging and guides was prepared in this way, so that work could be started at several places at once. As each gauge-piling engine completed the driving of a sufficient number of gauge-piles a sheet-piling engine followed it up. The lower lengths of several sheet-piles were first driven; their upper lengths were then riveted on, and the driving was completed.

Behind the platform on which the piling-engines stood was a line of railway, along which were brought the boilers for driving the engines. These were 6 h.-p. and 8 h.-p. vertical boilers mounted on cars, and were connected with the engines by flexible armored hose. They were brought down when the tide had receded sufficiently, and drawn up on shore again at the close of the working-period.

The driving-gear for the gauge-piles comprised a 30-cwt. monkey, 22-cwt. dolly and 3¼-cwt. driving-head or cap, all of Hadfield toughened steel. For the sheet-piles a similar monkey was used, but the dolly and cap weighed 19½ cwt. and 4¾ cwt. respectively. On the top of the driving-cap, between it and the dolly, was placed a pad of compressed fiber, 1⅛ in. thick, to diminish jarring; while in the case of the sheet-pile gear a strip of copper was also beaten into the groove in the cap which fitted over the head of the pile, for the same purpose. At an early stage of the work difficulties were frequently experienced with the attachments of this gear, the monkey-eyes, gauge-bolts, and cotters becoming crystalline after a few hours' work and breaking. Various qualities of steel and other metals and alloys were tried for these parts of the gear, but eventually a return was made to commercial iron of good quality, rubber pads being inserted between the parts to reduce the jarring; and this increased considerably the life of the attachments, and of the monkeys, etc.

In driving the gauge-piles, any tendency shown by the pile to run outwards from the machine or in towards it was counteracted by packing up the engine at either the back or the front, and so giving it an inclination outwards or inwards, which had the desired effect in bringing the pile back to the plumb; while to check any tendency to run sideways a winch with blocks and tackle was provided, by which a strain was kept on the head of the pile in the necessary direction.

Some very hard ground was met with in driving the steel piles, and as an aid in driving through this ground a water-jet was used. The water was delivered from the pumps by a 5-in. pipe, diminishing to 3 in. and again to 1½ in. in diameter; from this a 1¼-in. vertical pipe led to the jet-pipes, of which there were two, springing from a T-joint and coming down in front of and behind the pile respectively. These down pipes were tapered to a point ¾ in. in diameter. The pipes were kept working up and down by hand by means of a block and tackle, the points being kept about level with or slightly below the point of the pile. It had been feared that the use of these jets might unduly disturb the surrounding ground, leaving permanent ill-effects; but experiments made before the regular adoption of the system proved that such was not the case. After one tide had flowed over the ground it became fairly hard again, and after three or four tides it was found to have returned to its normal consistency. The points of these jet-pipes were not allowed, save in exceptional cases, to be put down lower than 8 ft. above the finished level of the point of the pile. The jet was used in driving the sheet-piles only, as the gauge-piles could not have been satisfactorily guided had it been used for them.

In certain exceptional cases, periods of very hard driving of sheet-piles were experienced. Some of these were caused by meeting with obstructions, probably small boulders, in the gravel bed, as they usually occurred during the passage of the point of the pile through this stratum. In one case a pile which had progressed at about the ordinary speed until 7 ft. from the finished depth, met with such an obstruction at this point; the driving became gradually harder, until at 3 ft. from the finish 160 blows of the monkey were required to drive 1 in., the pile apparently carrying the obstruction down with it. Then the obstruction appeared to be gradually pushed aside, as the driving became easier, although still hard, the driving for the last 2 ft. being at the rate of 48 blows per inch. Occasional hard driving of the sheet-piles also occurred, where the gauge-piles had not been driven quite truly and the sheet-pile ground against either the face of the flange, or the sides of the jaws, of the gauge-pile. In one instance the sheet-pile evidently cut into the flange of the gauge-pile, as it began to carry the latter down with it. An attempt was made to draw the sheet-pile, but without success, and eventually the gauge-pile was driven down by means of a special dolly until the sheet-pile was released, when the latter was driven to finished depth at about the normal rate of driving. The gap which was necessarily left between the two adjoining sheet-piles by this extra driving of the gauge-pile was closed by a plate, secured to each sheet-pile by fishplates.

With the gauge-piles abnormally hard driving was not very frequently experienced. Occasionally, however, a pile would be diverted from its course to too great an extent to permit of the deviation being rectified by the manipulation of the piling-engine or side-winch to which reference has been made; such piles were drawn by means of hydraulic jacks and repitched, the second attempt to drive them usually proving successful. Where, however, it was evident that an obstruction existed, either to gauge-pile or to sheet-pile, which would entirely prevent the pile from being driven, a caisson was sunk and the obstacle was removed. On some occasions it was necessary to sink both in front of and behind the line of piling, and two caissons were therefore provided. These caissons were 6 ft. wide by 5 ft. across, and were formed of steel plate stiffened by T-bars. They were made in sections, each 3 ft. deep, having flanges formed of angle-bars, so that the successive sections could be bolted together as the sinking proceeded. The bottom length was provided with a cutting edge. By this means obstacles were removed on several occasions. The largest of these were met with in the clay bed and consisted of granite boulders.

When the piles had been driven until their heads stood 2 ft. 3 in. above ground-level the adjacent ground was excavated and filled with puddled clay in the manner already described in the case of the timber sheet-piling. The total length of cut-off formed by steel piling was 4,636 ft., the various lengths used being: 34-ft. 6-in. piles, 1,720 ft.; 31-ft. 6-in. piles, 1,258 ft.; and 25-ft. 6-in. piles, 1,658 ft.

The top of the main outer limestone bank is 15 feet above high-water level of ordinary spring-tides, this bank having an extreme height of 40 ft. above the foreshore. The top of the inner bank is at high-water level, while that of the clay hearting is at an upward incline of 1 in 40 landward from the inner edge of the main limestone bank, its landward side being sloped down to meet the outer edge of the lower stone bank.

The main limestone bank is 10 ft. wide at the top, exclusive of the width of the protective coating of larger material. It has slopes of 1 to 1 on the landward and 1½ to 1 on the seaward side. The bank was not in the first instance formed to its full height, but was kept 5 to 6 ft. below this, in order to provide sufficient width for the requisite number of construction-roads on the top; the upper layer was deposited later, as the progress of the work permitted.

The stone was obtained from quarries adjacent to the east end of the work, and consisted of large and small material mingled together, a preponderance of the larger being used as far as possible for the sides of the banks, especially the seaward side. The practice in tipping this bank was to keep two tip-heads working, with end-tip wagons, following up at intervals with side-tipped material. For tipping the larger material in the main bank, and also the protective coating of large limestone lumps, special wagons were built, the end-tipping wagons to carry 12 tons and the side-tipping 15 tons. The former had wheels 3 ft. in diameter, this increase in size over that of the wheels of ordinary tip-wagons being found advantageous, inasmuch as the wagons ran much more easily, and also were more readily spragged.

The covering of 25-ton concrete blocks, with which the central portion of the barrier is faced, is 25 ft. in width, and consists generally of successive tiers of two blocks, each placed at right angles to the line of the work, so that their ends are presented to the stroke of the sea. These blocks are not placed flat on their beds, but are deposited as irregularly as was consistent with avoidance of an undue proportion of interstices in the work, and with securing a sufficient weight of block-work. The blocks measured 11x6x6 ft., and the concrete was composed of 6 parts of sand and shingle to 1 part of cement, having also a proportion, not exceeding 20 per cent. in the case of any block, of large rough stones incorporated in it.

Molds were provided for forty blocks, and floor-space for making twice that number, a mold being removed from a block when set and moved on to the site for making the neighboring block. The molds were usually loosened after 48 hours and removed after 4 days, and the block was lifted and conveyed to the stacking-ground after about 10 days, the minimum being 7 days. No block was set in the work until it was 4 months old, and stacking-ground was therefore provided for 1,100 blocks. A full week's output from the block-makers was fifty-six blocks.

For handling the blocks in the yard, and for setting them in the work, Goliath cranes of 60-ft. span were used. The blocks were lifted for stacking and loading by means of lewis-bars, but for depositing them in the work nippers were used. The cranes for setting the blocks were carried on staging formed of iron girders carried on dolphins of four piles each. The blocks were taken out along the limestone bank alongside the staging to the Goliath, which lifted them, passed them through an aperture in its side frame, and duly set them in place. The best day's work accomplished was fifty-one blocks, but it was seldom that more than twenty to twenty-five blocks were set in a day. The total number of 25-ton blocks set in the work was 5,157; and in addition to these the 200 20-ton blocks which had protected the weakened portion of the first sea-wall were removed from their position and placed in the new work after the closing of the outer barrier. Over the top of the block-work, which was at a level 5 feet below the top of the bank, being thus 10 feet above high water of ordinary spring-tides, a covering of rough limestone, similar to that which protects the shoreward ends of the embankment, and of the same width (15 feet), was deposited.

As the two ends of the banks progressed seaward, considerable scour began to take place immediately in front of them, caused by the flow and ebb of the tide around the ends. In order to prevent this, a covering of a mixture of clay and debris from the mines was spread in advance of the work. This mixture was of a very heavy nature and it also consolidated soon, becoming eventually quite hard and affording practically complete protection against scour. An apron of similar material was also spread at the foot of the wave-breaker blocks over the length where the sea-stroke was heaviest, and prevented the abstraction of sand from this place and consequent sinkage of the blocks.

The inner bank was intended, as already stated, to be formed of iron slag, and a considerable length was executed in this material. It was found, however, that the weight of the slag was not sufficient to prevent its being clawed down and squandered whenever seas of any strength occurred, and its use was discontinued in favor of limestone until the sea had been excluded, after which a return to the use of slag was made for the remaining portion of this bank. The inner bank was 9 feet wide at the top, with slopes of 1 to 1, and was deposited by end-tipping wagons, the landward side being subsequently trimmed to the desired slope.

When these two stone banks had been tipped for sufficient lengths, and the hollow before described had been excavated between them and filled with puddle, the clay bank followed. The material was deposited in a similar manner to the stone bank, commencing with two end tips, the valley left between the two tips being afterwards filled by side-tipping, which was also carried on from the stone banks. This clay was chopped, watered, and rammed as it was deposited.

Simultaneously with the tipping of the ordinary clay filling the construction of the puddle wall was proceeded with. The wall was brought up in steps of 1 foot, at a slope slightly flatter than the end of the tip, the ordinary clay, side-tipped from off the stone banks, being carefully packed and rammed against its sides as it was raised. The puddle was conveyed by wooden shoots from the top of the bank to the wall, and was deposited therein by hand, being well trodden in to render the mass homogeneous. The wall was 7 ft. wide at the foot where it sprang from the puddled trench, or from the puddled hollow around the heads of the piles, and was continued at this width up to 5 ft. below high-water level of ordinary spring-tides, when the width was reduced to 5 ft., the wall being carried 10 feet higher at this width.

The surface of the clay filling, which varies in width between 43 and 58 ft., is finished with a layer of slag 6 in. thick, well rolled with a heavy roller. The slag coating was not applied until the clay had been deposited for several months.

For closing the dam there was built a single-skin timber dam, 292 ft. in length, with coffer-dams 65 ft. long at each end. The dam was situated slightly to the east of the center of the work, and a short distance west of the permanent culverts. It was constructed in the line of the embankment, its face being 5 ft. landward of the steel piling, and the banks were advanced so as to house in the dam to the extent of 83 ft. at each end, the coffer-dams enclosing the puddle wall.

The quantity of water contained behind the barrier at high water of ordinary spring-tides was calculated to be 105,000,000 cubic feet, and for its inflow and outlet thirty-six sluices, 6x4 ft. 4 in., were provided in the dam, the permanent sluices, which were also taken into account, having an area of 66¼ sq. ft. The sills of the sluices in the dam were 17 ft. below high water of ordinary spring-tides, being 4 ft. above those of the permanent sluices. The top of the dam was 8 ft. above high water of ordinary spring-tides. The main piles were 16x16 in., and were driven 24 ft. into the ground or 15 ft. into the clay bed. The sheet-piles, which were 6 in. thick, were driven so as to extend not less than 10 ft. into the clay. The sluices were arranged in six bays of six sluices each, with a counterfort between each bay. Where the sluices occurred, and for the portion enclosed in the banks, the main piles were spaced 4 ft. 4 in. apart, and at the counterforts 5 ft. 4 in. apart.

After the main piles and the sheet-piles had been driven, and during the erection of the superstructure of the dam, the ground between its face and the steel piling was excavated down to the clay bed and the space was filled with puddle. The hollow between the stone banks was also excavated, and the puddle was deposited, the latter being covered with a coating of mine-debris before fixing the decking of the dam, up to the underside of which it was brought. The decking, which was 5 in. thick, extended for a width of 48 ft. in front and 38 ft. behind the skin of the dam, and the space between the underside of the decking and the ground was filled with mine-debris over which a layer of clay was laid immediately before the planking was laid down. This was to prevent scour from taking place beneath the decking. The coffer-dams at the ends were formed by driving a row of piles 10 ft. 8 in. in front of the main piles and fixing thereon 6-in. timbers placed horizontally: with the 6-in. vertical cleading of the dam, this formed a casing which was filled with puddle in continuation of the puddle wall. The row of piles was continued to form the outer row of the gantry on which the cranes for construction purposes, and subsequently for raising and lowering the sluice-doors, were carried. The inner row of gantry-piles was the same distance behind the main piles of the dam.

The construction of the dam was practically completed on July 14th, 1904, and 6 days later the closing of the sluices took place, the permanent culverts being closed immediately afterwards. Operations were then suspended two days, when, all having proved satisfactory, the sluice-doors were calked and pitched and a beginning was made with stripping the decking of the dam and removing the coating of mine-debris over the puddle in the trench and hollows. At the same time tipping of slag in the inner bank was proceeded with. The tipping of the main limestone banks was pushed forward, in order to protect the dam, with all possible speed. When these banks had been brought forward to within 30 ft. of one another, a strong gale and heavy sea occurred, but no damage of any kind was sustained. The upper portion of the gantry was removed after the clay filling had been brought up.

After the barrier had been closed, water was observed issuing in runnels from certain places at the foot of the inner stone bank. It was at first surmised that it might be water which had been held up in the embankment and land-water draining out through the stone. It was found, however, that while this might account for some of the runnels nearest to the shore, which ran continuously, it did not account for the majority, as it was soon observed that these were affected by the tide, beginning to appear at 2 to 2½ hours before high water, and disappearing at 3 to 3½ hours after the ebb had begun. Moreover, as the tide rose, the surface of the sand inside the barrier for a distance of about 150 ft. from it became damp and assumed an appearance of sweating; while as the tide neared its full height, small bubbles appeared, forming small craters in which the sand was kept moving by the water. The force of the water, however, was not sufficient to carry the sand away; nor did there appear at any time to be any material being borne by these bubbles, or by the runnels already mentioned. The sweating usually began about 45 minutes earlier than the runnels, and continued considerably longer.

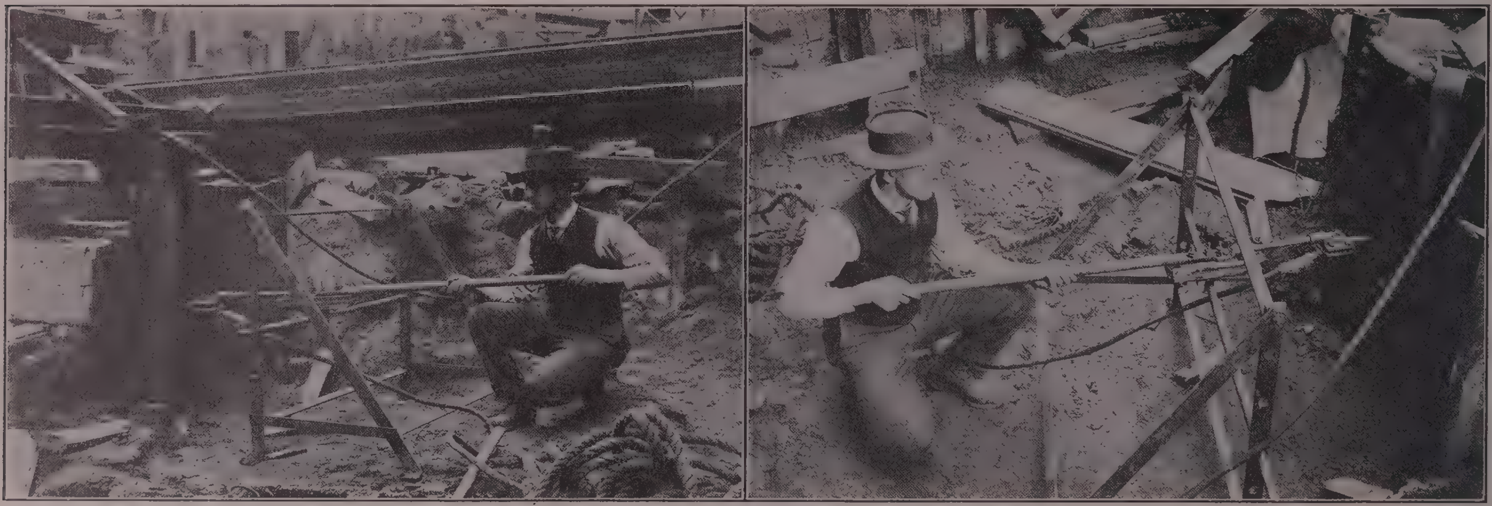
These indications appeared over a length of about 1,000 ft., behind that portion of the barrier where the cut-off was formed by 34½-ft. steel piling at the west end of the work, and consequently where the ground was known to be most unreliable; and it was believed that the weight of water outside the barrier caused the moisture with which the sand was charged to be forced under the steel piling and to the surface inside. In order to check this action it was decided to apply a plaster of clay over the spot, making the weight of this sufficient to counterbalance the pressure on the sea side of the embankment. A patch of clay was accordingly deposited, covering with a good margin that part of the ground where the dampness and sweating had been observed. The depth of water at high water of spring-tides outside the barrier at this part is 15 ft. 6 in., and at the highest recorded tide it would be 20 ft. The height of the clay filling was therefore made 10 ft. 6 in. against the side of the inner stone bank, and a gradient of 1 in 60 was given to the surface, giving an average height of 9 ft. The weight of the clay being 125 lb. per cubic foot, this gave a weight of 1,312 lb. per square foot on the ground at the foot of the embankment, or an average weight, over the whole area covered, of 1,125 lb. per square foot, the pressure of the water outside being 1,280 lb. at the highest recorded tide and 992 lb. per square foot at high water of ordinary spring-tides. The surface of the clay was covered with a coating of slag in a similar manner to the main bank. Since this clay patch was deposited no indication of sweating beyond its boundaries has been observed, and only a very small quantity of water has been seen to issue from the stone bank at a point a short distance below the end of the patch.

In order to prevent the ground immediately in front of the culverts from being scoured away by the necessary periodical openings of the sluices a small apron of mine-debris has been deposited there.

The Hydro-Electric Plant of the Albany Power & Manufacturing Co. is one of the first large water-power developments undertaken in Southern Georgia. It is on the Muckafoonee River at a point where precipitous rocky banks make the site especially favorable. The dam, which is of concrete resting on and abutting against a limestone formation, is 360 ft. long, 20 ft. high, and has in its center a spillway 150 ft. long. The power house is a brick structure 30 x 80 ft. There are four 900-h.-p. Morgan-Smith turbines and two 500-kw. General Electric three-phase revolving field generators. The turbines are of the horizontal radial inward-flow type and are direct-connected to the generators. Eventually there will be four generators, two being at present held in reserve. The transmission lines are three in number. Two run 1½ miles to Albany, with which the power company has a contract, and the third supplies power to large fertilizer works ¾ mile distant. The plant was designed by Mr. J. E. Sirrine, of Greenville, S. C., and was constructed by Mr. B. H. Hardaway, of Columbus, Ga., under the supervision of Mr. W. D. Dent.

Cutting Off Steel Piling by Electricity.

Electricity is being put to a novel use in the construction of the new Hoffman House, at Broadway and Twenty-fifth St., New York City, in the cutting of large masses of metal which were inaccessible and expensive to remove by ordinary methods. In the preparation of the foundations, Friestedt Interlocking steel sheet-piling has been used, being driven to bed rock to permit excavations for foundation footings. Owing to the unevenness of the underlying rock, however, the piling projected unevenly above the desired foundation level and in a number of places necessitated cutting off the upper end of the piles so as not to project above the basement floor level. Drilling was resorted to for this purpose, but proved to be an extremely slow process and very expensive. Owing to the success which had been attained in some places in cutting steel structural shapes, by means of the electric arc, it was decided to make a trial of the process in this instance.

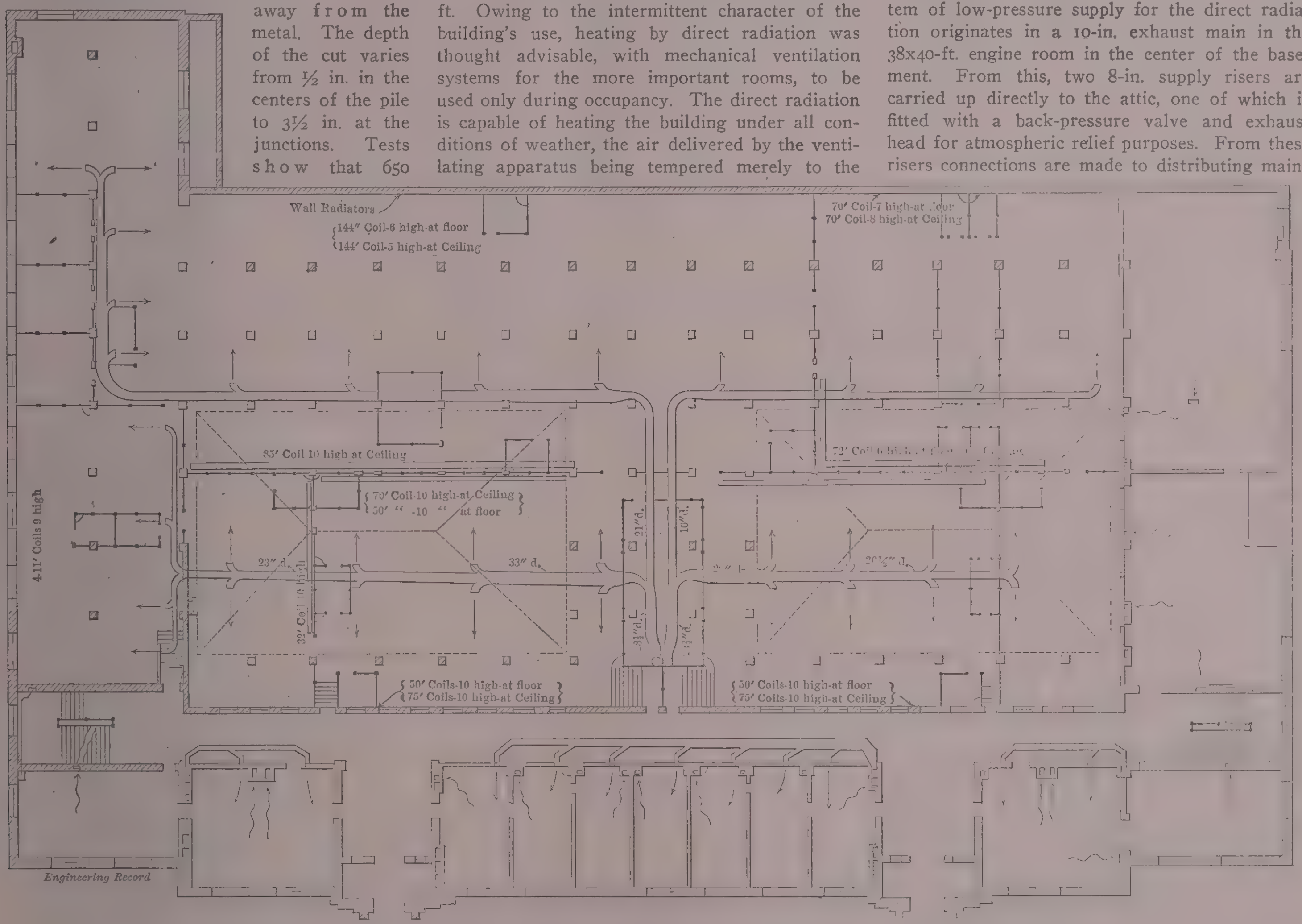

View Showing Apparatus for Cutting off Steel Sheet Piling with the Electric Arc.

As electric current was available from mains in Broadway, an independent power plant was unnecessary and a temporary connection was made to the street circuits. It was found impossible to utilize the Edison direct-current lines owing to throwing the three-wire system out of balance, so alternating current was utilized from the 2,500-volt, single-phase lines of the United Electric Light & Power Co. Current was supplied at this voltage to four 20-kw. transformers, wound for 50 volts at the secondaries, which were connected in multiple for large current capacity. In making preliminary tests of this method the arc was operated at 25, 50 and 100 volts, but most satisfactorily at 50 volts, which was finally utilized.

One wire is bolted to the sheet piling to be cut while the other is connected to a carbon electrode, which is mounted in a connecting clamp at the end of a long wooden guiding handle. The electrode is adapted from a carbon brush 1¼x¾ in. in section and 12 in. long, bolted between two plates of copper 5 in. square by ½ in. thick. The connection to the plates is made by a clamp lug, for, owing to the intense heat to which the device is subjected, any other form of connection would not be permanent. As it is, the copper plates buckle so seriously from the heat that, after fifteen hours' use new ones must be provided.

It is found necessary for the workmen to wear masks of asbestos and gloves of the same material to protect them from the heat and effects of the arc. The mask is fitted with double black glass, which deadens the glare, but permits the operator to just distinguish the arc. The arc may thus be carefully scrutinized without any injury to the eyes or skin, during the cutting process. When first tried no protection was thought necessary; but it was found that even when working at a distance of 11 ft. from the arc the carbon dust and fumes caused blistering of the skin and festering of the lips of the operator, an excessive flow of water from the eyes, and at night intense pain was felt in the eyes.

The arrangement of the cutting electrode and supporting rack is clearly shown in the accompanying illustrations. The circuit is completed from the transformers through the electrode and piling, without extra resistance, the operator merely touching the carbon electrodes against the iron and thus forming the arc; once started care is exercised by the operator that the arc is not disrupted by pulling the electrode too far away from the metal. The depth of the cut varies from ½ in. in the centers of the pile to 3½ in. at the junctions. Tests show that 650 amp. are consumed at the arc, and, at a potential of 50 volts, this is equivalent to a consumption of 32 kw. In a day of eight hours it has been found that 10 ft. of piling can be cut through with this device with an energy consumption of 250 kw.-hours. The wages of the attendant is $4.00 per day, and even with energy at a rate as high as 10 cents per kw.-hour the total cost of operation is in round numbers $30 per day, or $3.00 per foot of piling cut.


Wall Radiators
144″ Coil-6 high-at floor
144′ Coil-5 high-at Ceiling
70′ Coil-7 high-at floor
70′ Coil-8 high-at Ceiling
85′ Coil 10 high at Ceiling
70′ Coil-10 high-at Ceiling
50′ " -10 " at floor
72′ Coil
23″ d.
33″ d.
21″d.
10″d.
31½″d.
13″d.
20½″ d.
32′ Coil 10 high
4-11′ Coils 9 high
50′ Coils-10 high-at floor
75′ Coils-10 high-at Ceiling
50′ Coils-10 high-at floor
75′ Coils-10 high-at Ceiling
Engineering Record

Main Floor Plan of the Engineering Building, Showing Heating and Ventilating Systems.

With the use of electric drills it has been found that two men were required to cut through a foot of piling in a day. The wages of these two men was $9.00 and the energy consumption of the drills was 44 kw.-hours. With energy at the same rate as above, this would cost at the rate of $13.40 per foot of piling cut. Neglecting entirely the question of economy of time, which is all-important in New York building operations, the arc cutting device shows a saving of over foot. The actual saving is more than this, since with the energy consumption of the arc cutting device and considering that it is a day load, the rate would be less than 10 cents per kw.-hour.

Heating and Ventilation of the Engineering Building at the University of Pennsylvania.

The new building for the Engineering Departments of the University of Pennsylvania, containing the mechanical, electrical, hydraulic and cement testing laboratories, was described in The Engineering Record for Oct. 20, and the equipment of the cement testing laboratory was mentioned on November 3. It is a three-story and basement building 300 ft long and 160 ft. wide, with a 40-ft. ell at one end. The basement extends under only about one-third of the structure. The entire working floor area of the building, excluding halls, etc., amounts to 128,000 sq. ft. Owing to the intermittent character of the building's use, heating by direct radiation was thought advisable, with mechanical ventilation systems for the more important rooms, to be used only during occupancy. The direct radiation is capable of heating the building under all conditions of weather, the air delivered by the ventilating apparatus being tempered merely to the temperature of the interior of the building. An interesting feature of the installation is the provision of distant control of the fan motors, by which they may be started from convenient locations in the sections served, as required.

Direct Radiation.—The direct radiation has been distributed to counteract direct window and wall exposure and in proportions designed on the thermal unit basis of heat loss. The heating surface has been given the usual locations under windows in all rooms and underneath skylighting in the laboratories on the first floor. The amounts of surface placed in the different rooms varies somewhat with the direction of exposure, but the installation was considerably simplified by the fact that the building faces southward, so that the principal class rooms have favorable exposure. On the second and third floors there are long, narrow rooms devoted to drawing, which, on account of facing northward and having window exposure on both sides, introduced difficult heating conditions. In those rooms on the second floor 813 sq. ft. of radiation have been installed for 8,000 sq. ft. of floor area, while those on the third floor have 1,366 sq. ft. of radiation for a floor area of 11,300 sq. ft. In the main laboratory a combination of side wall coils for heating and ceiling coils for snow melting was used, the lighting of this room being by skylight only.

The steam supply for the direct radiation is furnished from the central power plant of the university, the steam being distributed at high pressure through underground mains to the various buildings and there reduced to the pressure required for the heating systems. In the engineering building, arrangements are made to utilize the exhaust from the engines operating electrical generating machinery, with provisions for live steam supply when the engines are not in operation or the exhaust is insufficient. The system of low-pressure supply for the direct radiation originates in a 10-in. exhaust main in the 38x40-ft. engine room in the center of the basement. From this, two 8-in. supply risers are carried up directly to the attic, one of which is fitted with a back-pressure valve and exhaust head for atmospheric relief purposes. From these risers connections are made to distributing mains that supply the heating risers, all radiation being supplied on the down-feed system. There are three groups of attic distributing mains, one following the outer walls of the building and a ring main surrounding each of the two interior courts. Each 8-in. riser divides at the top into horizontal branches, as indicated in the attic plan, and these branches are extended to connect with the ring and outside mains. These distributing mains are divided by cut-off valves into eight distinct sections for convenience of isolating the equipment of any section of the building for repairs. The ring mains are mainly of 1½-in. pipe, while the outside distributing mains range from 5 in. down as the branches are taken off to the risers.

There are forty-nine drop risers, the greater part of which are of 1¼-in. pipe, reducing to 1 in. at the lower floor levels. These risers are free to expand in both directions, for which swiveling connections are provided at the supply branches in the attic and in the drip connections at their bases. The connections in the attic are short horizontal branches between the tops of the risers and short vertical nipples from the distributing main, swiveling being allowed by double elbows at either end of the horizontal connections. This arrangement is used for all branch connections from each section of distributing main except for the last riser, where the swiveling connection is made by a vertical nipple extended downward from the main to provide for drainage. The drop risers are all connected direct to the supply mains without valves in the branch connections.

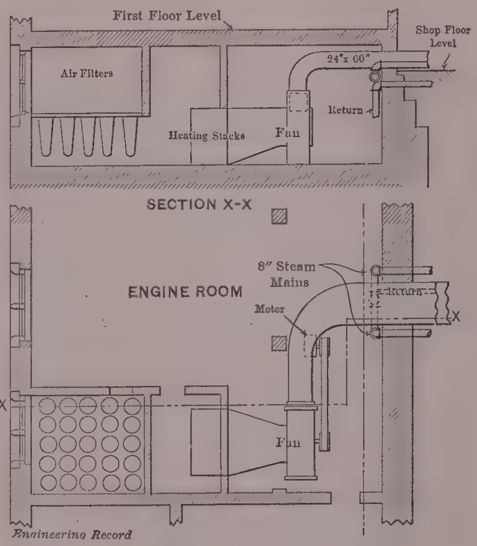
The radiation is operated on the two pipe system, all drop risers being paralleled by return risers for the return of condensation from the radiation to the power plant. The 55 return risers start as ¾-in. pipe and their diameter is increased as they descend in proportion to the radiation drained. Those carried up to the attic are for the tempering coils of the ventilating systems, which are of 2½-in. pipe, enlarging to 3 or 3½-in. pipe. They all connect in the first floor or basement, through swiveling connections, into systems of gathering mains, corresponding with the supply systems in the attic. All water of condensation is returned by gravity to a sealed tank, from which it is returned to the power plant by a pump, under automatic control of a float. The return mains and the distributing mains in the attic, are graded for the drainage of condensation and are fitted with air vents. There is, in addition, an auxiliary system of drips, consisting of a bleeder connection from the base of each drop riser. These bleeders connect into an auxiliary return main which parallels the main return system, but is of smaller size. This auxiliary system is connected to an independent steam trap discharging into the main return tank. This arrangement provides for the delivery of steam to the radiation in the driest possible condition, and is a factor insuring noiseless operation of the system.

An unusual feature of the installation is the use of pipe coil radiators formed of 1-in. wrought-iron pipe with return bends, ranging from 4 to 11 pipes high. These are used in practically all rooms of the building, exceptions being the corridors and the students' assembly room on the second floor where two-column cast-iron radiators are used. The coils are located as near the window casings as possible to allow return connections to be carried under them, and in no case are the coils carried above them. The manifold coils where used are so shaped and hung that all portions are graded 1 in. in 20 ft. in the direction of the flow of steam for drainage. The radiators and coils are fitted with Jenkins union globe valves, the sizes being 1 in. for coils containing 300 ft. of 1-in. pipe, 1½-in. for coils up to 500 ft. and 2-in. for coils having over 500 ft. of pipe. The return valves of return bend coils are Jenkins ¾-in. lock-shield check type for radiators having less than 300 ft. of 1-in. pipe. All manifold coils have Jenkins union globe valves for returns, ¾-in. return for 1-in. supply, 1¼-in. return for 1½-in. supply, and 1½-in. return for all larger coils.

An adjunct to the heating system is the hot-water generator in the basement. It is a 75-h.-p. Wainwright feed water heater which has been adapted for this purpose by connection to the exhaust system, water being admitted within the casing and surrounding the tubes, and steam circulating inside the tubes. A connection is also made to the high-pressure steam system through a 1-in. reducing valve, to supplement the low-pressure supply when necessary. Condensation is removed by a trapped drip connection which discharges into the main return tank. The hot water supply for the building is stored in a large tank to which circulating connections are made from the heater.

Ventilation.—Practically all of the class, drawing and assembly rooms on all three floors and the large mechanical and electrical laboratories on the main floor are provided with mechanical ventilation, for which fans having a total capacity of nearly 50,000 cu. ft. of air per minute have been installed. The fans for the class room supply are in the attic, in which unused space was utilized for the equipment which is to include air filters and tempering coils. Only in the case of the system supplying the mechanical and electrical laboratories, is the fan installed in the basement. The attic fans supplying the drawing rooms are controlled from the drawing room offices, those ventilating the auditorium and students' assembly room are controlled from the switchboard in the engine room, and the class room systems are operated from the east and west ends of the first floor.

The ventilation of the upper floors is divided into five systems, each operated by a 60-in. full-housed fan in the attic having a capacity of 5,600 cu. ft. of air per minute at ½ oz. pressure. These fans have air intakes through louvred openings in the roof, from which it is intended to make short, direct connections to the air filter enclosures. The latter are to consist of galvanized-iron casings in which cheesecloth air filters of the bag type are arranged, the capacity of surface of filtering medium installed being sufficient to permit a reduction of flow velocity through the filter to not over 50 ft. per minute at full capacity of the fan. Between the filters and the fans are located the tempering coils. Each fan is driven by a 2-h.-p. direct-connected motor operated upon the 110-volt power circuit of the building. Each motor has a speed range from one-half to full speed, by field control, which is obtained by rheostats located on the motor bases, while the starting boxes are at distant points as described above.



Engineering Record

Details of Main Floor Ventilating System.

Each ventilating fan supplies a different section of the building, as indicated in the accompanying attic plan. The fans are grouped in the central portion of the attic, equipments A and B supplying the west and east halves respectively of the front division, equipment C the middle wing between the two interior courts, and equipments D and E, the west and east halves of the rear divisions of the building. Delivery connections from the fans are in most cases made through ducts in the attic to vertical ducts furred into the wall construction. An exception occurs on the third floor in which distributing ducts concealed in the ceiling finish supply certain of the rooms at the front side of the building; this auxiliary duct work is connected through the corridor ceiling to the attic distributing systems. Similar arrangements of distributing duct work concealed in furred corridor ceilings occur also on the second and first floors, these auxiliary duct systems being supplied by large connections through "breathing wall" partitions in the front portion of the building.

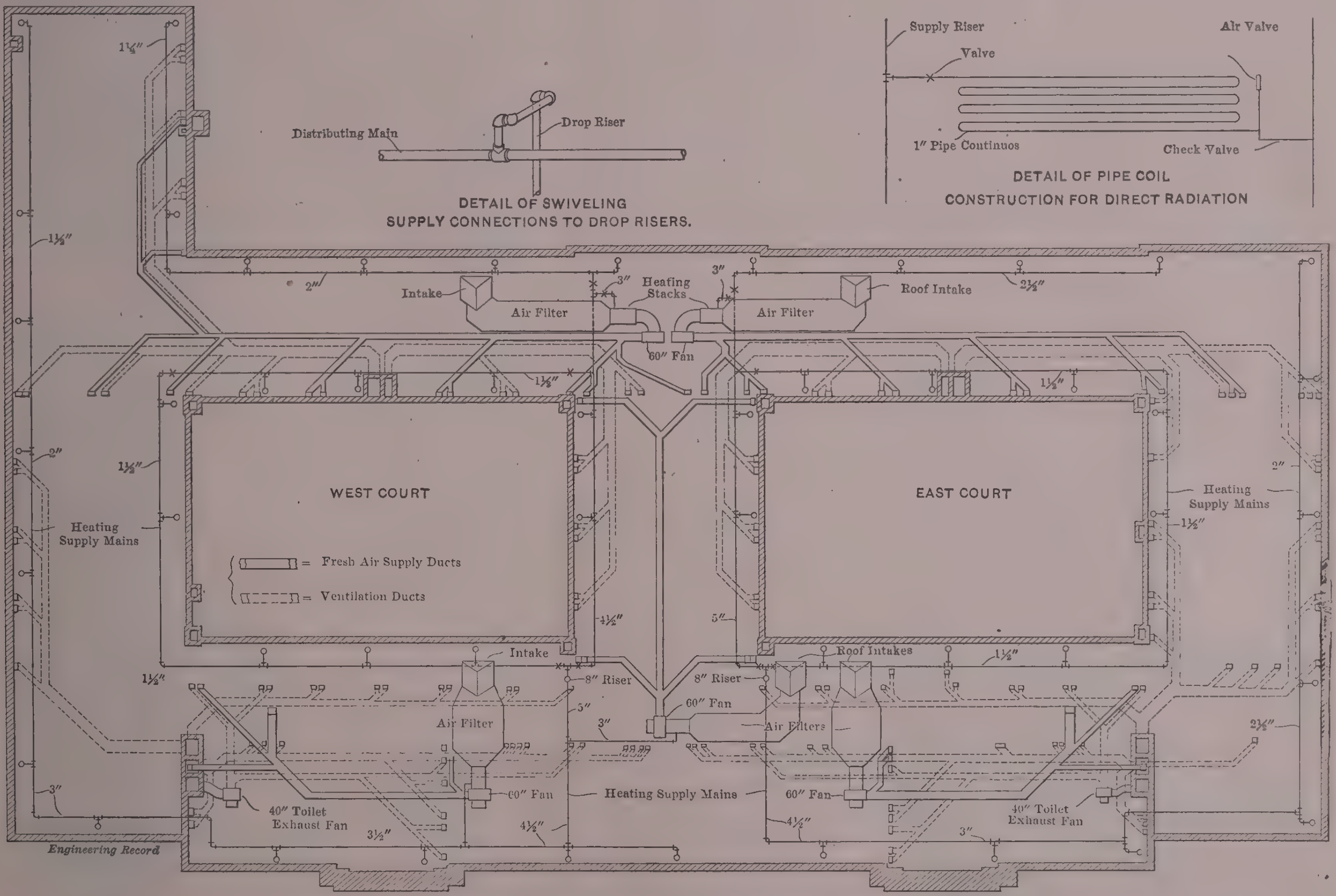
All rooms are ventilated on the downward system, registers being located about 8 ft. above the floor, while the vents are at or near the floor line. The proportions of supply in the various rooms have been figured to furnish 30 cu. ft. of air per minute per person with maximum occupancy, according to legal requirements. The register openings are considerably larger than the ducts supplying them in order to produce low velocities of delivery. The distributing ducts are designed for comparatively high velocities, ranging from 1,400 to 1,600 ft. per minute, which are, however, reduced in the branches and outlets to 500 ft. per minute or less.

The tempering coils in the fan intake connections between the air filters and the fan casings are designed to raise the entire volume of air delivered by the fan at maximum capacity from zero at the intake to 70° Fahr. at delivery. To accomplish this the coils have been designed with amounts of linear feet of 1-in. pipe used for heating surface of not less than 1/250 of the volume of air supplied by the fan per hour. The five attic fans, while of the same size, are called upon for varying duties as follows: Equipment A, 5,200 cu. ft. per minute; B, 4,900 cu. ft.; C, 3,800 cu. ft.; D, 5,600 cu. ft.; E, 3,800 cu. ft., and the basement fan equipment, 21,500 cu. ft. The tempering coils are arranged in general in four-pipe sections, and all are under the Powers system of automatic temperature control. Each coil is controlled by three thermostats, one on the intake side of the coil and two in the fan discharge, this provision being made for the purpose of turning heat on the outside coil when the fan is not in operation and the coils would otherwise be exposed to freezing temperature outside. The inside thermostats are set to maintain the air discharged at 70°, while the outside thermostat is arranged to throw steam into the outer sections when the intake temperature drops below 32°. Compressed air for the temperature regulation system is furnished by an electrically-driven air pump with pressure controller and storage tank in the basement, from which connections are made to the thermostats and motor valves in the attic.

The basement supply system consists of a 120-in. steel plate fan in the engine room, with an air intake through an adjoining basement window. This fan discharges through ducts carried near the ceiling line of the mechanical and electrical laboratories. The fan, tempering coils and air filter are compactly arranged at one side of the engine room, the fan being of the full-housed top horizontal discharge type. The air filter is like those of the attic equipments and has twenty-five 20-in. cheese-cloth bags, each 5 ft. long, which are hung vertically from a horizontal deck. The area of filtering medium thus provided is sufficient to produce a low velocity through the filters, not exceeding 50 ft. per minute at maximum capacity of the fan. The fan is located just outside the filtering chamber, the intake connection being through a galvanized duct in which the tempering coils are located.

The 20x60-in. discharge duct of this fan is carried up through an enclosure in the mechanical laboratory and divides into two circular galvanized-iron ceiling distributing ducts, one of which is 28½ in. in diameter and the other 24½ in. These branches are again subdivided into two distributing mains each, one group supplying the eastern section of the laboratories and the other the west portion. The delivery connections from the fan up into the laboratories are necessarily of comparatively small size, but as branches are taken off they increase in size to produce reduced velocities as the outlet branches are approached. The main discharge connection is proportioned for a velocity of over 2,000 ft. per minute, but this is reduced at the branch duct connections to 1,000 ft. and less, while at the outlets it is reduced to less than 500 ft. per minute. The arrangement of distributing mains and outlet branches is shown in the accompanying first floor plan.

Ventilation has been provided in all rooms of the building whether fitted for fresh air supply or not, by vents connected to the chimneys. In rooms where there is fresh air supply, ventilation is on the plenum system. Only in the toilet rooms is the air removed by mechanical ventilation, these rooms not being fitted for fresh air supply. The vent ducts for the various rooms are in most cases concealed, like those for fresh air supply, in furred wall construction, those of the fan systems having register openings at or near the floor line for ventilation on the downward system. The vents from the rooms on the fan systems are connected in the attic space by gathering duct lines which lead to chimney vent openings. The small offices on the second and third floors facing the interior courts and those rooms not occupied by a number of men or for long periods, are not supplied with fresh air from the fans, but are ventilated through registers, located near the ceiling, which, like those of the other rooms, are connected to the vent chimneys by a system of natural draft flues, with gathering system in the attic.



Arrangement of Heating Supply Mains and Ventilating Systems in the Attic.

Cope and Stewardson, Philadelphia, Pa., are the architects for the building. All heating and lighting plans for University buildings are prepared under the direction of Prof. H. W. Spangler, who has charge of the mechanical and electrical engineering courses.

A Telegraph Line Across the Sahara Desert is under construction by the French Government. It has been built from the City of Algiers to the Oasis of Tonat, and will follow thence an old caravan trail to Timbuctoo and ending at the port of Dakar, on the Atlantic coast, in the Province of Senegal. The total length of the line will be nearly 3,000 miles.

The Tumwater Plant of the Olympia Light & Power Co.

The Olympia Light & Power Co., which supplies light and electric power to Olympia, Wash., has replaced its old plant with a new installation. At Tumwater, 2½ miles from the business section of Olympia, the Deschutes River has a mean fall of 86 ft. over rock ledges in a series of three cascades into the tidal water of "Budd's Inlet," an arm of Puget Sound. The old plant was located at the foot of the middle falls and operated under a head of 46 ft., generating about 375 h.-p. The water was brought down in a wooden pressure flume 1,000 ft. long and 10 ft. square inside. The new plant is at the foot of the lowest cascade and when the projected storage reservoirs have been constructed will be able to develop about 3,000 h.-p. These storage reservoirs are necessary because of the great difference between the dry and wet season flow of the river.

The best site for the plant was found on the opposite side of the river from the wooden flume. In order to use the old flume it was therefore necessary to carry a pipe line or a continuation of the flume across two chasms formed by the erosive action of the river. A flume was considered impracticable because of the pressure to be sustained. A calculation showed 9 ft. to be the diameter required for a pipe to supply the 450 second feet of water, necessary to generate 3,000 working h.-p. at 86 ft. head. The total length of new pipe required was 600 ft. A wooden stave pipe would have been cheaper and in other ways preferable to a steel pipe but, owing to the fact that a connection must be made between the pipe line and a steel stand pipe just outside the power house, where a horizontal thrust of 145,000 lb. would occur at an elbow, it was thought advisable to use a steel pipe. Tank steel was specified for all plates and double riveting on long seams and single on round seams. The conditions governing the design of the stand pipe were, that it should be large enough to quietly discharge over its top the rush of water caused by the wheel gates being suddenly closed by the governors, and to provide a supply of water without too great a drop in head, when the wheel gates are suddenly thrown wide open and the required velocity of 7 ft. per second is being acquired in the main pipe line. With these conditions in mind a pipe 7 ft. in diameter was decided on.

In making the connection between the wooden flume and the steel pipe a section of flume was built around the end of the old flume and carried out a short distance beyond the end of the steel pipe, which has a 4x4x5/16-in. angle riveted around it on the outside about 12 in. from its end. Planking was then fitted between the pipe and the sides of the flume and caulked with oakum, being held in place by the angle and by timbers bolted to the frame. The pipe is carried across the two chasms by a bridge and a trestle structure. The bridge is a four-panel steel span, 84 ft. from center to center of end pins and 21 ft. deep. The trestle is a combination of concrete piers located close together and I-beam stringers supported by struts which are riveted to the bottom flanges and anchored to the piers near their bottoms.

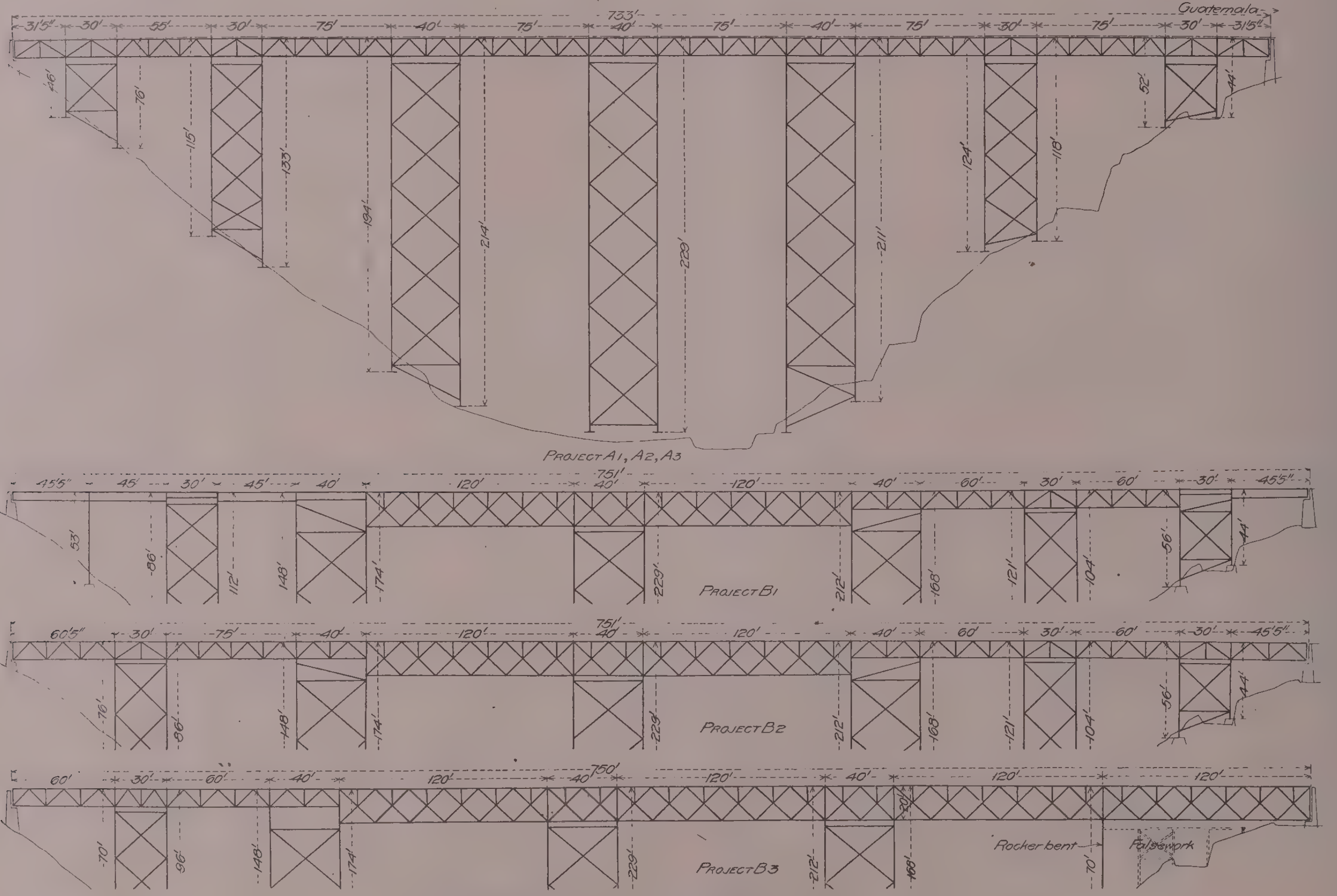
The power house is built of Tenio sandstone and rests on solid rock. The mechanical equipment consists of two 500-kw. Westinghouse generators each direct-connected to a pair of 24-in. horizontal shaft, Victor turbines made by the Stilwell-Bierce & Smith-Vaile Co. These turbines are of the inward discharge type, each pair being enclosed in a steel case and discharging through a tapered draft tube, 4 ft. in diameter at the upper end and 4½ ft. at the lower end. A vacuum gauge attached to one of the tubes shows 15-in. vacuum at low tide and 5 in. at high water. The water wheel gates are controlled by two type "D" Lombard governors. The Pacific Bridge Co., Portland, Oregon, was the general contractor for the installation of the entire plant. The plant is described by Mr. E. W. Cummins, Consulting Engineer, Seattle, Wash., in a paper, published by the Pacific Northwest Society of Engineers, from which these notes are taken. Mr. Frank R. Chambers, Jr., was the assistant engineer and Mr. J. B. C. Lockwood is credited with the design of the 84-ft. bridge.

Investigation of Shop Ventilation in New York City.

The ventilation of eight shops in New York City has been investigated by Dr. Marriott of the Cornell Medical College with results that are considered unsatisfactory. The test used was the determination of the carbon dioxide in the air. In lower New York this averages, he says, about 4.5 parts per 10,000, and he assumed that not more than 6.5 parts should be present in a well-ventilated room, in addition to the gas due to the open lights. The worst place showed 16.2 parts of carbon dioxide although the legal ventilating requirement was complied with. Four gas jets contributed 2.48 parts of the gas and the remainder came from respiration, it is reported. In all cases the law was complied with, and in most cases the ventilation was not bad. These statements are being circulated so widely that attention should be drawn to the fact that carbon dioxide is not an accurate index of the quality of air unless all the sources from which it comes are carefully determined. These are not always easy to ascertain, and it is possible to make a large error in ascertaining the amount of the gas given off by lamps and gas jets.

Bridges and Viaducts on the Guatemala Ry.

The extension of the old Guatemala Northern Ry. from El Rancho into Guatemala City, a distance of about 60 miles, is now nearing completion by a new organization known as the Guatemala Railway Co. This company was organized about three years ago with Mr. Minor C. Keith as president, and under a concession from the Gauatemala government took over the property of the Northern Ry., which was then in operation from Puerto Barrios, on the Gulf of Amatique, on the Atlantic Coast, to El Rancho, about 134 miles. This road, the property of the government of Guatemala, was commenced in 1883 under the administration of Gen. Rufino Barrios, then president of the republic. It was projected to extend from the Gulf of Amatique to Guatemala City, about 196 miles, where a connection would be made with the Central Ry., also a 3-ft. gauge road, which was then in operation between Guatemala City and San Jose on the Pacific Coast, a distance of about 75 miles. A 12-mile extension of the Central Ry. from Obero to the port of Iztapa, on the Pacific, a few miles east of San Jose, was also projected. This project comprehended extensive improvements of the port of Iztapa, and would have formed a through line from the Atlantic to the Pacific. The construction of the Northern Ry. was suspended in 1885 on account of the death of President Rufino Barrios. Considerable grading on the first 62 miles had been done, but only a few miles of track had been laid.



Alternative Plans for Las Vacas Viaduct.

The work was taken up again in 1892 when contracts were made with Sylvanus Miller, under which, in 1897, the road was completed from Puerto Barrios to El Rancho, a distance of 134.2 miles. The further extension of the road was delayed by the death of Gen. Jose Maria Barrios, then president of Guatemala, and the unfavorable financial condition of the country. The extension of the Central Ry. from Obero to Iztapa was also completed and a considerable quantity of rails and rolling stock was purchased, together with the necessary right of way and lands for the terminus in Guatemala City. A start was also made in the improvements of the port of Iztapa.

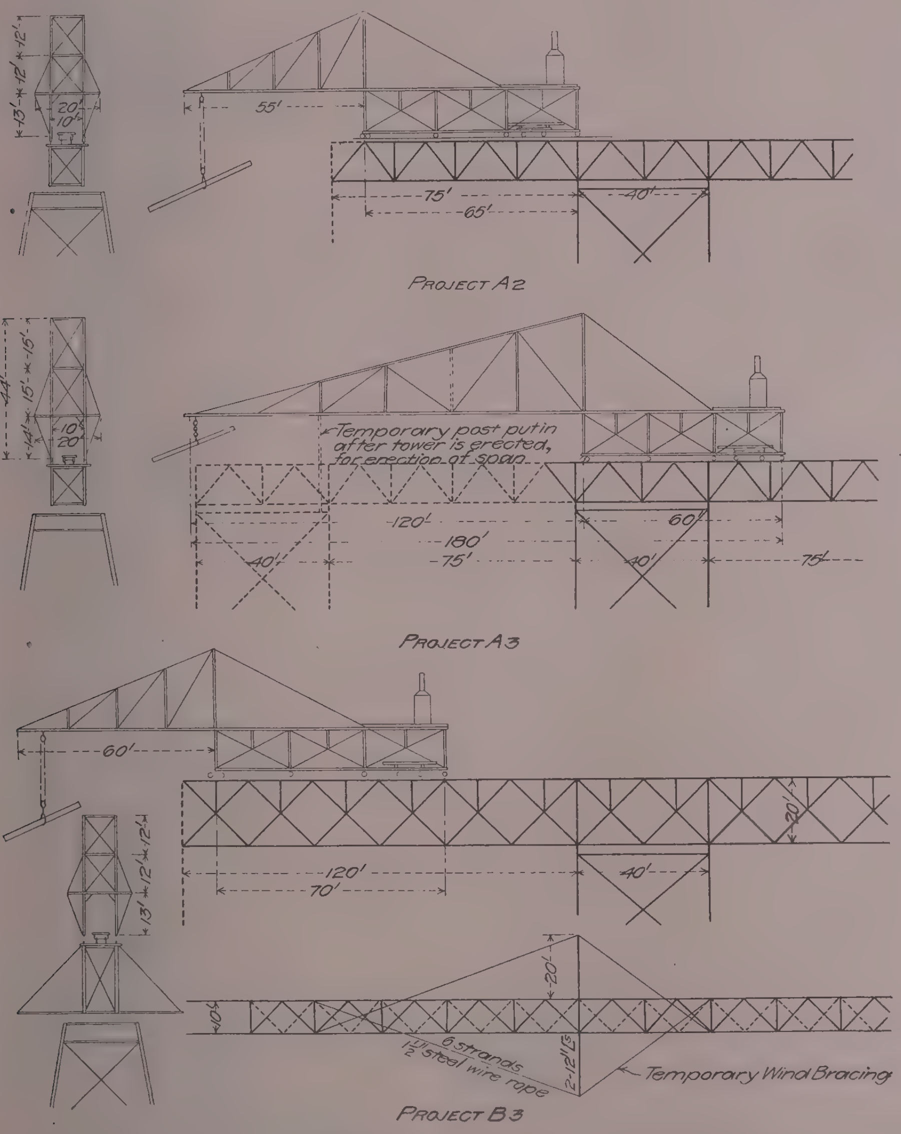
Since 1897, the Northern Ry. has been operated between Puerto Barrios and El Rancho by lessees. Under the leases the property deteriorated, little being expended for maintenance. When the present company took over the property, it became necessary to make very expensive repairs and additions to both roadway and rolling stock, almost amounting to reconstructing the line, and under their concession to extend the line immediately into Guatemala City. The 3-ft. gauge of the track has been retained, but the bridges and roadbed have been made a sufficient width to accommodate a standard gauge road if, in the future, it should appear desirable to change the gauge.

The total length of the main line of the Guatemala Ry., from Puerto Barrios to Gautemala City, will be about 195 miles, and by its connection with the Central Ry., the line will be about 270 miles in length from Puerto Barrios on the Atlantic Coast to San Jose and Iztapa on the Pacific. This route is the only one from the Atlantic Coast to Guatemala City which does not encounter very difficult grades, making the cost of construction and operation prohibitive.

The population of Guatemala City, the capital, is stated at 70,000 and of the entire Republic at 1,300,000. There are at present about 375 miles of railways in operation in Guatemala, which will be increased to about 435 miles when the extension described in these notes is opened to traffic. In addition to the lines above mentioned, there is a line of the Central Ry. from Esquintla to Mazatanango; the Occidental Ry. between

Mazatanango and Champerico, a distance of about 42 miles; a line extending about 25 miles inland from Ocos on the Pacific and another 28 miles in length from Panzos, which has water connection with Livingston on the Atlantic Coast.

The 60 miles between El Rancho and Guatemala City is in a very high mountainous country which required much heavier work than the other parts of the line. The old line on the Atlantic slope had twenty-three truss bridges, comprising thirty-four spans from 61 ft. to 178 ft. in length, or a total of 3,915 ft. There were also sixty-three girder spans from 25 ft. to 62 ft. in length, or a total of 1,999 ft. In addition to the above, there were many short trestles and small openings, making a total of 4,700 lineal feet. The total length of truss bridges, girder bridges, trestles and small openings was 10,614 lin. ft. A number of these bridges were carried on cylinder piers and in several cases cylinder piers were used for the abutments. These were frequently washed out by freshets. They are being rebuilt with new foundations carried down to greater depths, the whole line is being resurfaced with ballast, and the original 54-lb. rails, which were in good condition, are being relaid on creosoted yellow pine ties imported from the United States.



Types of Traveler Suggested for Erection of Las Vacas Viaduct.

In the 60 miles of new line between El Rancho and Guatemala City there are three summit levels, the highest one about 5,000 ft. above the sea. The cuts are 16 ft. wide and embankments 12 ft. wide. The limit of curvature is 19 deg. and the maximum grade is 3 per cent. Three short tunnels will be constructed, and fifty-seven new bridges with an estimated total weight of about 6,000,000 lb. are under construction. These include maximum spans of 180 ft., a three-hinged arch of 212 ft. span, and ten viaducts with a maximum height of 230 ft. The viaduct spans for ordinary erection are plate girders from 30 to 60 ft. in length, but when the assisted cantilever method of erection was adopted, riveted trusses were used for the viaducts with intermediate spans of about 75 ft., between the towers, except in one instance where there are three riveted truss spans of 105 ft. each. Intermediate viaduct spans vary from 30 to 105 ft. in length, but 45-ft. spans predominate. The tower spans are 30 to 40 ft., the latter being used only in the highest towers. The longest viaduct is 743 ft. in length and 230 ft. in height; another one 235 ft. long and only 33 ft. high has been built on an 18-deg. curve and a 2.28 per cent. grade.

A general report and thorough studies, comparative preliminary designs and estimates were made by Mr. Virgil G. Bogue, consulting engineer. He analyzed several different plans for viaducts for each of the principal valley crossings and recommended the most advantageous ones, which have been adopted and are now under construction. The superstructures are proportioned for a loading of two mogul engines of 73.5 tons each, coupled, followed by a uniform train load of 2,500 lb. per lineal foot of track. The bridge superstructures conform to standard railway specifications except in some features where special provisions have been made.

For the Las Vacas viaduct, 230 ft. high from top of lowest pier to base of rail, Mr. Bogue presented six alternate plans. The design of the superstructure for the first three plans was identical, and they differed only in the methods of erection. The plan recommended by Mr. Bogue was accepted and the bridge is now being erected. The arrangement and dimensions of spans and towers and the system of bracing are shown on the accompanying diagrams, to which are added partial diagrams showing the varying features of the comparative designs.

All of the following estimates of quantities and cost were made only for the purpose of comparing the relative merits of the several designs considered. Items common to all, such as end abutments and floor, were entirely omitted and the prices used were only appriximate.

In all of the "A" plans, the masonry substructure is identical and its estimated cost is $8,960. The net weight of steel required for the structure after erection is 1,569,000 lb. (This weight was subsequently increased by changes to adapt the design to European shapes and to certain limitations of shipping and handling.) In the A_1 plan, it was proposed to erect the towers by cableway and to erect the spans on level ground on the Guatemala side, and launch them to position by the method of protrusion over wheels or fixed rollers, thus involving an additional weight of 52,000 lb. of steel to provide for temporary erection stress, making the total amount of steel 1,621,000 lb., which at a price, erected, of $91,790, makes the total cost $100,750. In plan A_2 it was proposed to erect the spans by the cantilever method, building the towers from their overhanging ends with a traveler of 55-ft. reach. In this case 72,000 lb. of extra steel were required to provide for temporary erection stress, making a total of 1,641,000 lb. at $84,050, and bringing the total cost of the viaduct up to $93,010. In plan A_3 it was proposed to erect both towers and spans with a traveler 180 ft. long, having an overhang of 120 ft. This did not require any extra steel and the 1,569,000 lb. required for the structure was estimated to cost, as in the other cases, 5 cents a pound, making $83,850 for the superstructure and a total of $92,810 for the finished viaduct.

Plan B_1 required six towers and one rocker bent supporting spans of 30 to 120 ft. in length, made of plate girders and riveted trusses. It was proposed to erect the towers by cableway, to erect the truss spans on level ground at the Guatemala side and launch them by protrusion over wheels or fixed rollers, and to erect the plate girders with a short overhanging traveler or from the cableway. The total amount of steel required was 1,633,000 lb., costing, erected, $89,330, which, with the $8,320 sub-structure, made a total of $97,650.

For Plan B_2 the proposed system of erection was the same as for Plan B_1, except that the short riveted spans on the Sanarate side were to be erected by the cantilever method with a short traveler on the cableway. The 1,663,000 lb. of steel cost $90,830 erected, and the sub-structure $7,680, making a total of $98,510.

In Plan B_3 it was proposed to erect the 120-ft. approach span on the Guatemala side on falsework, erect the rocker bent from the overhanging end of the span and complete the erection with a traveler 130 ft. long having a 60-ft. overhang. The 1,641,000 lb. of steel cost $84,750, erected, and the masonry cost $7,470, making a total of $92,220.

In all of the B plans from 60,000 lb. to 70,000 lb. of steel have been added to the net sections to provide for temporary erection stresses and the extra costs of traveler, cableway and falsework have been estimated separately and added to the assumed price of 5 cents per pound for the steel. The end abutment masonry is common to all plans and is not included in the estimates of cost.

In all cases the weight and cost of the erection plant were carefully calculated, the estimated salvage was subtracted from it and the remainder was added to the cost of the steel work for the cost of the superstructure, including the labor of erection.

In Plan A_2, which was adopted, it was noted that in the final design a saving of about $1,000 would be effected by increasing the depths of the trusses to 12 ft., which was not the case with the other plans. In Plan A_3, it was considered that the dimensions of the 120-ft. overhang and 40-ft. height of the traveler were somewhat hazardous on account of the limited base provided by the narrow deck of the structure, only 10 or 12 ft. wide. In plan B_3 it was necessary to allow for very heavy winds during erection sufficient to produce a maximum uplift of 100,000 lb. on a windward column.

In comparing the different plans, Mr. Bogue stated that "The estimated costs of A_2, A_3, and B_3 would be about equal and that A_3 should be eliminated because of the risk involved in using the traveler in a windy country with an overhang or reach of 120 ft. and a height of 40 ft. above the rail on a deck only 12 ft. wide.

"Project A_2, with a total cost only $200 greater than A_3, has about 72,000 lb. more metal in the spans. It is better to have extra weight of metal in the permanent work where it will add to the value of the structure.

"Projects A_1, B_1 and B_2, all of which are based on the launching method of erection, are found to cost from $5,000 to $7,740 more than Projects A_2 and B_3 which are designed for cantilever erection. This confirms American experience, which has uniformly favored the cantilever method.

"The launching method presents advantage in the erection of spans on the level ground, but this advantage is offset by the slow and tedious method of erecting towers by cableway. It should be noted that the expense of preparing the ground on the Guatemala side of the baranca for the launching method has been neglected. Whatever this amounts to, plus any necessary falsework or flooring, should be added to the total cost of Projects A_1, B_1 and B_2.

"The cantilever method presents no more risk than does that of launching out, and we therefore consider Projects A_2 and B_3 as better than either of the others. In practice the A_2 design would be changed, so that the trusses would be 12 ft. instead of 10 ft. deep, and this would make a saving of about $1,000. Projects A_2 and B_3, on this assumption, would cost practically the same, that is, about $93,000.

"In Project B_3 the wind stresses that may occur during erection, due to the necessity of using the 120 ft. of overhanging truss, plus the 60-ft. reach of traveler, making nearly 200 ft. in all, may become a serious element, the uplift at the foot of a windward column being possibly 100,000 lb., and requiring heavy anchorage and larger footings. Temporary wind guys are also required.

"While we have considered the cost of the metal, erected, to be 5 cents per lb. for all the different methods, it is evident that Project B_3 involves considerable risk which ought to be taken into account, and which would probably increase the cost.

"In our opinion, experience in this country in building bridges of this kind demonstrates that Project A_2 would, on the whole, give the best satisfaction, both as a permanent structure and in erection. It would also be rather a better-looking bridge than either of the others, the trusses having the same depth from end to end of the structure. In this country all the spans of Project A_2 would be plate girders; but, owing to the difficulty of shipment and of handling, we have designed riveted trusses for the Las Vacas viaduct. The parts of these trusses can be shipped in dimensions to suit shipping facilities."

Consideration was given in the report to a modification of the erection methods already described for Plans A_1, B_1 and B_2, which consisted in building the towers from the overhanging ends of the protruded spans after the latter were launched, instead of building them beforehand with cableways. These changes involved additional expense for more steel to provide for erection stresses for a short traveler and for an extra hoisting engine and boiler less salvage. For Plan A_1 these items amounted to $4,000 and were nearly offset by the saving of $3,500 effected by the omission of the cableway, thus reducing the net additional cost to $500. For Plans B_1 and B_2 the extra cost of $3,300 was less than the same saving of $3,500 for cableway, showing a net saving in total cost of the viaduct of $200. In all of these cases the probable saving in the labor of erecting the towers would be likely to be offset by the difficulty in handling the material for the towers over the rear spans, thus making it difficult to estimate the net result. These methods would also be objectionable on account of the wind stress involved by the long high overhang corresponding to those which were considered prohibitory for Plan B_3.

Besides the viaduct work and track construction, the railway company is making a headquarters at Zacapa, 100 miles from Puerto Barrious, where boarding-houses, offices, residences, machine shops and hospital have been built. At Puerton Barrious, there is also under construction in water 25 ft. deep a wooden pile pier 90 ft. wide with a 60x600-ft. steel shed. This building will be used principally for the storage of bananas and coffee, which form the bulk of the export freight handled by the line. In order to provide for the convenient handling of these articles, the double pitched roof of the shed is provided for about three-quarters of its length with special movable panels extending half-way from the ridge to the eaves. These panels are mounted on rollers and are counterweighted so that they can be easily lowered by hand, leaving traps or openings about 15 ft. square through which the freight can be vertically raised or lowered by trolley hoists running on the horizontal double cantilever arms of a steel traveler 40 ft. high. Two of these travelers are provided on each side of the building and run from end to end commanding both the interior of the shed and the holds of vessels moored alongside.

Mr. A. W. Buel is Mr. Bogue's associate on bridges, Mr. S. F. Shaw is chief engineer of the Guatemala Railway Co., and Mr. J. H. Pope is bridge engineer. The Baltimore Bridge Co. is the contractor for the steel, and Mr. W. T. Penny is the contractor for erection and track laying.

The Operation of the Philadelphia Filters during 1905 cost on an average $4.13 per million gallons filtered, exclusive of the water used in transporting and washing sand. The average cost per million gallons to scrape, transport, wash and restore sand to the beds was 79 cents at the Lower Roxborough station, 63 cents at Upper Roxborough, and $1.25 at Belmont. The high cost at Belmont is due to the fact that the applied water carries more suspended matter; it receives an average of only 2½ days' sedimentation, while at Lower Roxborough the water receives a day's sedimentation and is treated by preliminary filtration, and at Upper Roxborough the water receives about 15 days' sedimentation. This condition also causes a difference in the yield per million gallons per acre per run at the three stations, which was 141.15 at Lower Roxborough in 1905, 151 at Upper Roxborough, and 85 at Belmont. The average amount of sand removed per million gallons of water filtered was 0.88 cu. yd. at Lower Roxborough, 0.8 cu. yd. at Upper Roxborough, and 1.57 cu. yd. at Belmont.

The New Plant of the American Spiral Pipe Works.

For a number of years the American Spiral Pipe Works of Chicago have enjoyed a large trade in piping for long water-supply lines, hydro-electric plants, compressed air and exhaust steam mains and the like. Their business grew to such an extent that they were compelled to look for a new and larger site, and after careful consideration it was decided to stay as close as possible to the center of the city. They finally obtained four city blocks between 46th and 48th Aves., south of 14th St., where their new works have just been built, comprising a number of buildings. They have three-quarters of a mile of railroad on their grounds, connecting with the Western Indiana Belt R. R. and the Chicago Terminal Transfer R. R., which are the two main belt lines of Chicago, either of which connects with practically every road entering the city. This is a great advantage in obtaining cars for quick shipment.

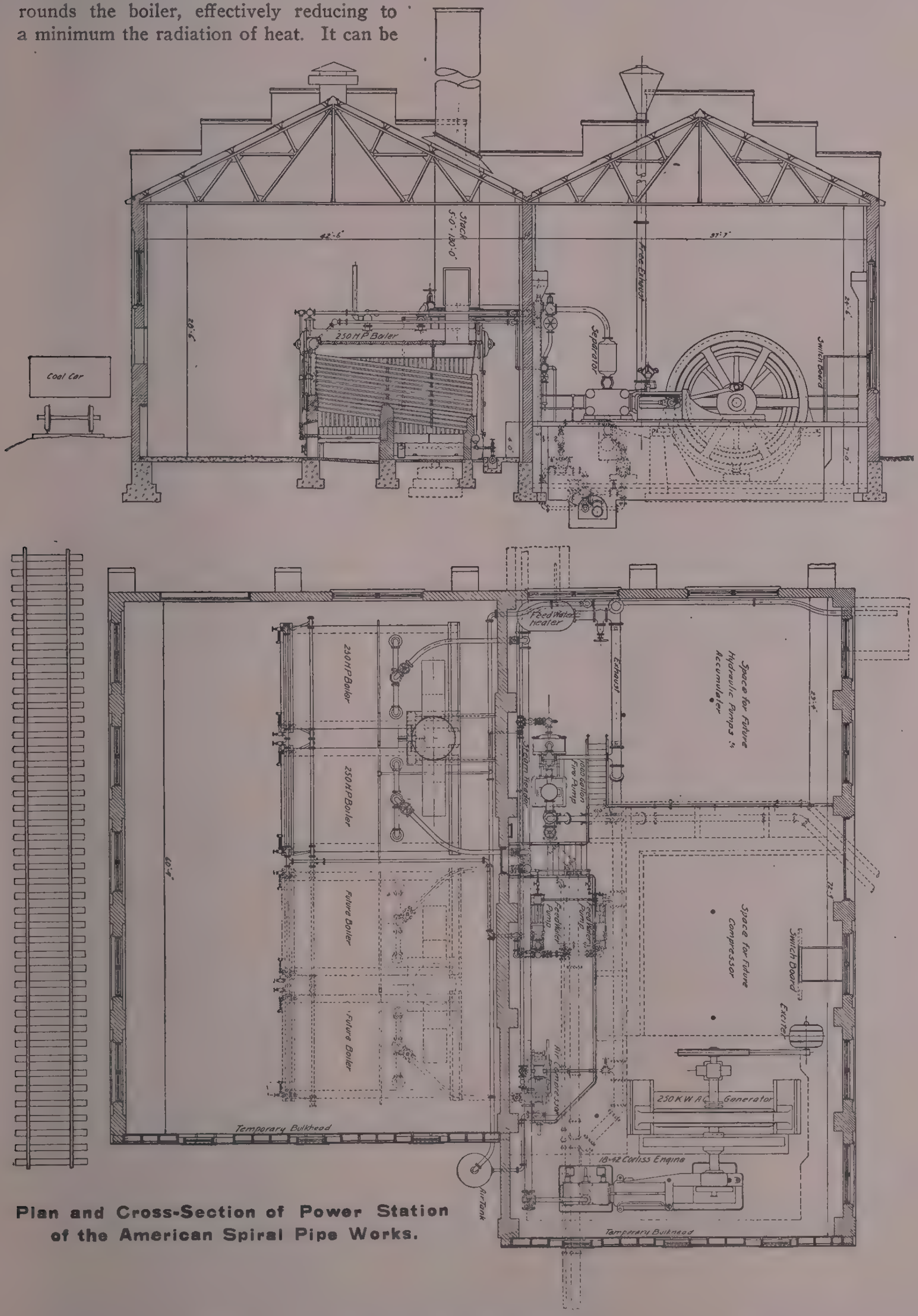
The main building, or pipe shop, of brick and mill construction, is well lighted by the saw-tooth roof. This building is devoted exclusively to the manufacture of spiral riveted pipe and heavy sheet-metal work. Adjoining the pipe shop is a material shed, of steel construction, where the steel plate used in the manufacture of spiral riveted pipe is received and stored. North of the main shop are the asphalting and galvanizing plants and the testing-room so arranged that the finished product may be tested and galvanized or coated with asphaltum on its way from the shop to the shipping-room. Parallel to and 50 ft. away from the pipe shop are the forge shop, machine shop, stockroom and shipping-room, all of brick and steel. The forge shop and shipping-room obtain light and ventilation from a monitor in the roof, and the machine shop from a saw-tooth roof similar to the main shop. The forge shop, where there are installed many heavy special machines, is devoted exclusively to the manufacture of forged and rolled steel flanges. Here large quantities of drop forgings, weighing from 100 to 400 lb. each, are handled with great ease and readiness.

The pipe and billet yard for a length of 600 ft. is served by a 5-ton, 50-ft. span Whiting electric crane.

At the entrance to the plant is the two-story brick office building, which is 40 ft. wide by 90 ft. long.

Just south of the material shed, fronting on the crane runway, is the 84x74-ft. power house, of brick and steel, except the east end, which is closed by a wooden bulkhead, allowing for future extension. The wall footings, machinery foundations, and floors are of concrete. The roof is corrugated galvanized iron lined with asbestos manufactured by Hyndman Steel Roofing Co., Cincinnati, Ohio.

The 60x42-ft. boiler-room has coal doors in the south wall, through which the coal is unloaded from a track running alongside. This is only a temporary arrangement, as a coal bunker is to be built in the future. One of the most interesting features of this plant is the boiler installation. There are installed two 300-h.-p. internally fired, high-pressure sectional water-tube boilers manufactured by the Munoz Boiler Co., Dayton, Ohio. By the arrangement of the drums and cross boxes, there is formed an arch of inclined tubes over the furnace. As the greater portion of the work in a water-tube boiler is done on that portion of the heating surface on which the fire impinges directly, the heating surface is so arranged that the greatest amount of it is nearest the fire. The casing, instead of being a mass of brickwork of great weight, requiring large foundations, consists of 4-in. tile set up directly against 4-in. vertical tubes on 6-in. centers. These tubes protect the tile, for, should the tile become hotter than the water in the boiler, the tubes would at once absorb the heat from the tile. In each section there are twelve of these tile placed one on top of the other, without fire clay or mortar. They are backed up by asbestos fire felt 2 in. thick, held in place by panels of steel plate. These panels weigh about 60 to 75 lb., and are held in position by small clamps, which make them very easily removed. This casing entirely surrounds the boiler, effectively reducing to a minimum the radiation of heat. It can be removed from the boiler in a couple of hours' time with two common laborers, and the entire pressure parts of the boiler exposed for cleaning, repairing or inspection.



Plan and Cross-Section of Power Station of the American Spiral Pipe Works.

The boilers are set individually, each unit being self-contained, with a space 4 ft. wide around. From this space there are eight points on each boiler, four on each side, from which to blow or remove soot from the tubes; they are so placed that it is possible to keep the boiler surfaces thoroughly clean while under operation.

The gases from each boiler are carried by steel breeching to a steel stack located between the boilers. The stack is 5 ft. in diameter, 130 ft. high, and stands on a cast-iron plate supported by a steel structure. In the space allotted for future boilers, there is temporarily installed a water gas generator of a capacity of 5,000 cu. ft. per hour, furnishing water gas for special forging and annealing work in the forge shop.

The 72x38-ft. engine-room has its floor line 4 ft. above that of the boiler-room. At the west end and along the partition wall is a pump pit, the floor line of which is 7 ft. below that of the engine-room. On this lower level are located the air compressor, two 500-h.-p. Gardner boiler feed pumps, a 1,000-gal. Buffalo fire pump, and a 1,200-h.-p. Stilwell feed-water heater. Sufficient space is also left for the hydraulic pumps and accumulator to be installed at an early date. On the engine-room floor proper is an 18x42-in., heavy-duty Corliss engine built by Filer & Stowell, direct connected to a National 250-kw., 220-volt, 60-cycle, 3-phase, alternating-current generator. A special feature of the alternator is the use of widely separated pole pieces, which construction requires a spider of large diameter and prevents crowding of the coils; thus the coils have a large radiating surface.

A 2-panel switchboard built by the Western Electric Co. distributes current for lighting and power purposes to the entire plant. The board is of black enamel slate. Each panel is 24 x 90 in., divided into two sections. All feeders and generator leads are protected by three-pole, double-coil I. T. E. circuit breakers, mounted directly on the slate. The instruments are Westinghouse flush mounted type E. Generator leads are carried to the switchboard in tile ducts laid in the floor.

The pipe, fittings and valves in the plant were furnished by the Pittsburg Valve Foundry & Construction Co., except the exhaust steam and water mains, for which spiral-riveted pipe was used. The high-pressure steam piping is all fitted with forged steel flanges manufactured by the American Spiral Pipe Works. The high-pressure piping is covered with Keasbey & Mattison's 85 per cent. magnesia sectional covering.

Just east of the power house is a concrete reservoir of 150,000 gal. capacity, into which all roof drainage is turned. The floor of the reservoir is porous tile, which allows the surface water from the surrounding territory to collect and be used in the power house. In case the reservoir is empty, water from the city mains is used. The water mains and fire protection lines are of spiral riveted pipe laid underground. There is about 2,500 ft. of spiral pipe in the fire lines.

Cables lead from the switchboard in the engine-room to panel boards located in the various buildings. Open work is used throughout, the insulators carrying the cables being fastened to wood strips bolted to the lower chords of the roof trusses. Five panel boards control all the power circuits of the plant. From these cabinets branch circuits are run open overhead to the motors. The feeders enter the panels through the fuses, and fuses control the branch circuits, which are tapped off of polished copper bus bars mounted on the face of the panel. All power circuits are three-wire, three-phase. The lighting panels, twelve in number, are fed from the power panels, and are of the same general type as the latter. The branch circuits are two-wire, controlled by 10-ampere, double-pole knife switches. All panels are of slate mounted in dust-proof steel cabinets lined with slate. The motors are practically all mounted on brackets supported on the columns or brick walls of the building. They are three-phase, 250-volt, Westinghouse, General Electric, and National machines. The starting compensators were furnished by the Westinghouse and General Electric Companies, and are of the oil-insulated type. In general the tools are grouped in sections, such that the motor units run from 1 to 30 h.-p., each motor driving a line shaft from which machines are driven. There are a few individual motor-driven units.

Cooper Hewitt mercury arcs are used for the principal illumination, one arc being installed for a group of machines.

Mr. Wm. Thos. Branitzky, Chicago, had charge of the architectural features of the buildings; the power house layout and the general distribution system were designed by The Arnold Co., and the whole undertaking was under the personal supervision of Mr. J. Hall Taylor, vice-president and general manager of the American Spiral Pipe Works.

TWENTY TONS OF BRAKE SHOES per month are stated to be used up in the New York Subway. The brakes are applied, it is said, for nearly one-quarter of the total time of running upon the local train runs and for about ⅛ of the total running time of the express, or limited trains.

The Producer Gas Power Plant of the Gould Companies at Depew.

Among the papers read this week at the meeting of the American Society of Mechanical Engineers was one by Mr. J. R. Bibbins, on the producer gas power plant of the Gould companies at Depew, N. Y. This plant is operating week in and week out, 24 hours per day, 6½ days per week, on a fluctuating manufacturing load, with a fuel consumption one-half that of a modern steam plant of like character and suited to the same work. On an average of half load this 450-kw. plant ordinarily consumes from 2 to 2¼ lb. of coal per kilowatt-hour, and, on heavier loads, has reached as low a consumption as 1½ lb. per kilowatt-hour in regular daily running. During heavy loads the plant has repeatedly developed without the battery 530 kw. on maximum fluctuations which represents an overload of 18 per cent. rating. Furthermore, with the exception of the engineers in charge during the two watches, the plant is operated by attendants originally quite unskilled in gas work; up to the time the paper was written, however, no complete interruption of service, traceable to defective equipment, has been recorded.

The two manufacturing plants served by the power stations are devoted to the manufacture of storage batteries and railroad specialties, and each is electrically driven. The station contains three 150-kw. Westinghouse three-cylinder, vertical engines, direct connected to Westinghouse direct-current dynamos furnishing current at 250 volts. Loomis-Pettibone gas producers are employed. There are good railroad facilities for receiving coal and an adjoining pond supplies water for cooling and fire protection.

The engines operate on the four stroke cycle involving constant quality of mixture and throttling governing. The actual proportioning of gas and air is accomplished by two plug valves at the bottom and the top of the mixing chamber, respectively, each with graduated index. These valves may be set by hand at any time to accommodate varying qualities of gas. An automatic diaphragm pressure regulator reduces the pressure of the incoming gas to atmosphere at the engine.

A most important factor in the successful operation of the engines is the ignition apparatus. For increased security each igniter plug has two sets of points, each set independently connected. Should one set of points, through any cause, become unfit for use, a small double-throw switch may be reversed, thus turning the ignition current through the other points. In addition, three independent sources of current have been provided, all of the apparatus being contained in a central ignition cabinet. For starting, one of two 8-volt storage batteries is used. For running, a small ½-kw. motor generator unit is used delivering 110-volt current to the igniters through incandescent lamps, which furnish a valuable "tell-tale" for "open circuits," "grounded igniters" or "hanging fire" of igniters. These two sets of storage batteries are charged alternately through a bank of lamps from the motor generator or from the main station bus bar one or the other set being always available in an emergency. By means of small double-pole switches at the igniter cabinets, throwing over from the low to the high-tension system may be instantly accomplished without in the least disturbing the engines.

Starting the engines is accomplished as usual by compressed air drawn from a pipe connection to a compressed air line in the works or from the relay compressor. Although only 90 to 100 lb. pressure is ordinarily carried, yet the engines may readily be brought up, cold, to full running speed, within 30 to 40 seconds. With higher air pressure available, starting may be accomplished in even less time, as the mixture ignites more readily when quickly compressed, owing to the smaller opportunity for the dissipation of internal heat.

Another important part of the plant equipment is the circulating water system for cooling jackets, combustion chambers and exhaust valves. Motor-driven rotary pumps are ideally suited to this work on account of the moderate pressure required, about 25 lb. per square inch. Two of these pumps (one for relay) serve the engine plant while a third, of the two-stage turbine type, serves the gas producer scrubber in which a higher pressure is desirable. Although each pump is driven by a 15-h.-p. motor, the power ordinarily required is considerably less than this, especially in moderate and cold weather when the quantity of water supplied to the engines may be largely reduced by throttling the pump outlets.

The cooling pond has a normal depth of 10 ft. with a total capacity of about 1,000,000 gal. It is approximately semi-circular in plan and is divided radially into two compartments to separate the comparatively dirty scrubber water from the pure jacket water. All make-up water used at the plant is delivered to the pure water pond through the engine jackets. The excess overflows into the scrubber water pond and thence to the sewer. Cooling water for the engine is drawn from near the bottom through a screen house, while the hot jacket water is returned to the surface of the pond, about 150 ft. distant. During the progress of the water from inlet to outlet enough heat is dissipated to the earth and atmosphere to reduce the outlet water to the proper temperature. During periods of extreme heat and humidity when the cooling process is retarded, a larger quantity of water may be sent through the jackets to compensate for the smaller difference in temperature.

Some trouble has been experienced with the gas gates, due apparently to cumulative deposits of carbon, and frequently it becomes impossible to seat the valves tight. In work of this class it would seem that a parallel seated quick closing gate would be best suited, being self-cleaning, and the gas could be cut off almost instantly in case of emergency.

The engine exhausts all discharge into a cast-iron header running beneath the floor to a concrete exhaust well outside, serving as a muffler. Unfortunately, it is impossible to cool these exhausts by water sprays on account of the large amount of SO_2 in the gas. If water were used, as is the practice with natural gas, the piping would soon be destroyed by corrosion. As some 30 per cent. of the total heat value of the gas is lost in the exhaust, radiation is a somewhat disagreeable feature, especially in warm weather.

The muffler well is, to be sure, a common arrangement in gas power plants, but most certainly could be improved upon. First, the noxious products of combustion rising from the pit, although located in the open, are driven directly into the engine-room during certain prevailing winds to the great discomfort of the operators. Second, if the exhaust pit is carried to any considerable distance from the power house, a serious back pressure is imposed on the engines owing to the friction of the high-pressure exhausts on the internal surface of the main. Usually the well is located close to the building with a short standpipe. This outlet is almost invariably too small, resulting again in serious back pressure from throttling. And it usually occurs that sooner or later the structure is dismantled by sudden pressures due to delayed combustion or other causes. A more logical arrangement would seem to be as follows: (1) A brick or concrete exhaust well of large dimensions built next to the power house foundation wall and loosely filled with large broken rock; (2) a brick stack extending to the roof and built into the building structure integral with pilasters thus taking advantage of the reinforcement offered by the steel skeleton of the building; (3) simple sheet steel flap doors or louvres inserted in the roof of the exhaust pit and at two or three points in the chimney to relieve occasional local pressures. In this manner the noxious gases are easily taken care of by a flue of cheap construction, agreeable appearance, and ample capacity for any contingency.

Four men, two on a shift, operate the generating plant, the oilers and the two engineers, being formerly steam engine operators. While the producer is undergoing renovation on Sundays, the engines are also inspected in rotation, mixing valves flushed down with gasoline to remove lampblack deposits (likewise cylinders, now and then to keep the packing rings free), valves are ground in and igniters replaced when necessary, jacket deposits cleaned out when obstructed to any extent, and the engines generally adjusted. Reducing valves are also cleaned, at intervals, from carbon deposits. Practically the only trouble experienced thus far has been the occasional cutting of an exhaust valve, presumably due to cumulative carbon deposits on the valve seats. The lampblack has also occasioned some difficulty in lubricating valve stems. Igniters, of course, wear down gradually, but extras are always kept on hand and repointed as fast as necessary. Usually one igniter will last from six to nine months without repointing. Since commencing normal operation, engine repairs have been confined to these two items and are comparatively light considering the conditions of operation. Very little trouble has been experienced with lubrication, as the main working parts are automatically supplied by the splashing of oil. All oil used in outer bearings returns to the crank case to make up that lost through evaporation. When the oil reaches too high a level the excess is drawn off, filtered and used over in the bearings.

In starting and stopping the engines the attendants have acquired so much skill that the barring lever is seldom used. By manipulating the air valves just as the engine comes to rest it is not difficult to bring the air cams in starting position so that no time need be lost in barring the engine around to the position for starting.

A notable feature of the producer plant is that it is capable of gasifying bituminous coals without making quantities of tar. The process is intermittent, embodying the now more or less well known system of passing the green hydrocarbon distillates through a secondary fire bed which has previously been brought up to the proper temperature by blasting with air. Since the plant was started, a fair grade of soft coal has been used, averaging about 13,500 B.t.u. per pound. Although this coal presumably contains 35 per cent. of volatile matter, tar destruction in the producers is complete, but at the same time a considerable quantity of lampblack has resulted which has made it necessary to devise special means to handle this by-product. No attempt has been made to market it, as some is used in the preparation of paints for castings, etc.

Straight producer gas is not made directly, but water gas and air gas are made at alternate intervals of varying duration according to richness of the gas desired. In metallurgical plants the two gaseous products of the system are often handled separately, the water gas being used for heating furnaces on account of its high flame temperature and the blast gas in gas engines for power purposes. And it is an interesting fact that, although this blast gas would be absolutely unfit for any other use on account of its comparatively low calorific value—from 80 to 90

B.t.u. per cu. ft.—yet it is quite suitable for gas engine work, in that it is not at all snappy (as is water gas) and, therefore, permits of higher compression. At Depew the two gases are mixed in a single holder in the proportion generated.

In this system two producers constitute a unit. Usually it is desirable to have a separate unit on hand for relay purposes. Here this was especially necessary in order to provide an opportunity for freeing the producer from clinker formed during the week's run. At Depew a novel arrangement was first employed, in the form of a clover leaf with three producers united at top and bottom by T pipe connection with the necessary water-cooled valves. It was then possible to renew one producer fire per week in rotation, and at the same time save the cost of a fourth producer to complete the duplicate unit. Through no fault of this arrangement, however, it was not an entire success, owing to the difficulty in preventing the leakage of water gas into the idle producer through the valves. This difficulty has now been overcome and a complete relay plant, including scrubbing equipment, is provided in the adjoining producer building with sensibly better results than before.

A feature of the system is that all steam required is generated entirely from the sensible heat of the gases coming from the producers which would otherwise be wasted in cooling water. This condition, however, obtains only when the plant is heavily loaded. Running light it would be difficult to make sufficient steam to operate the producer auxiliaries. With the high "heats" necessary in the intermittent process, this represents an important saving. The boiler, however, requires weekly cleaning.

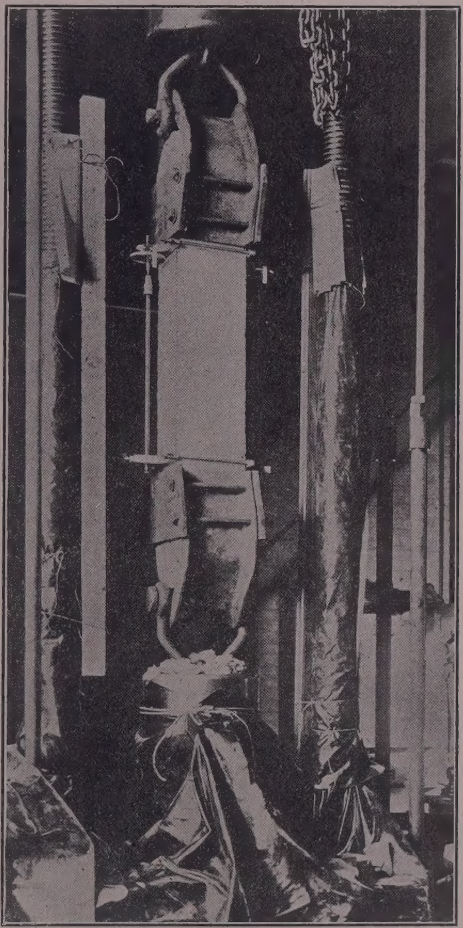
The proper cleaning of the gas is a difficult problem, owing to the fact that lampblack does not easily adhere to a wetted surface as does ordinary cinder dust. In this plant the gas first passes upward through a wet scrubber containing several tiers of small coke constantly wetted down by water sprays. A thin layer of dry excelsior is also used in the top tiers. Emerging from the wet scrubber, the gas enters two large dry scrubbers filled with several tiers of excelsior and piped up in parallel so that the velocity of the gas is not only reduced, but also the amount of gas handled by each drier. Finally, an engine driven Root exhauster delivers the gas to the holder.

The present method of operating the producer plant requires an air gas run of 10 to 15 minutes, according to the demand for gas at the power plant, and a water gas run from one-half to three-quarters of a minute, the resulting mixture being well suited to power work. Frequent testing of the quality of the gas made is not now practiced on account of its uniformity under the present operating condition. The holder, of course, greatly assists in insuring uniform gas at the engines. At the same time it provides sufficient capacity for operating one unit at full load for about three-quarters of an hour; the full plant in inversely proportionate time. Storage capacity is particularly valuable when a new fire is being put into service. This is usually done during the noon hour when the load is light, so that a lowering of the heat value of the gas is relatively unimportant.

In ordinary operation it is a simple matter to observe the quality of gas by means of two sampling flames always in view of the operators. One consumes gas from the holder; the other consumes freshly made gases as they leave the dry scrubber. Any irregularities may then be readily detected. Calorimeter tests show the gas as made at the present time to average slightly above 100 B.t.u. per cu. ft. This comparatively low heat value is, of course, due to the preponderating period of blasting. With the rate of water gas mixing practically fixed, the only variable factor to compensate for varying demands for gas is the rate of blasting; hence, there is a long and subdued air gas run with a rapid but short run on water gas.

For the starting layer of a new fire bed, coke is used to the extent of some 3,000 lb. per producer, a sufficient quantity to affect the coal consumption of the succeeding day. If allowed to form to any extent, clinker constitutes a frequent source of trouble in operating the plant, and it is important that the selection of coal be made with this in view. With fires fairly free from clinker the suction required for blasting may be only 8 to 10 in. of water, but with fires badly clinkered it may run up to 25 in. With 10 to 15 in. drop in the scrubbers, this imposes from 30 to 40 in. suction on the exhauster, thus largely increasing its steam consumption.

From the daily records of the plant an excellent idea of its operative efficiency may be obtained. These records, although not elaborate, are carefully kept and show not only the output and duty of the plant but also the maximum loads that occur during the hour. A digest of a typical day's run shows continuous operation except at noon and midnight to be exact, 97 per cent. of the elapsed time. The load averaged 263 kw., or 58 per cent. of the generating capacity in service with nine full load hourly maxima and five equivalent to 8 per cent. overload. The average coal consumption for all purposes was 1.98 lb per kilowatt-hour generated.



Concrete Tension Specimen in the Machine.

During a ten-day run the engines averaged 87¼ per cent. of the possible running time and on 54 per cent. station loading factor the plant consumed 2.04 lb. fuel per kilowatt-hour or 1.44 lb. per brake horse-power-hour.

With coal of 13,500 B.t.u. calorific value the efficiency of this plant averages about 13.1 per cent., thus rivaling the largest modern steam power stations. On one day the fuel rate was about 1¼ lb. per brake horse-power-hour, with 62 per cent. loading factor, corresponding to a plant efficiency of over 15 per cent.

Tension and Compression Tests of Concrete.

A series of tension and compression tests of concrete have been made at Columbia University, which are of interest because the specimens tested were of much larger dimensions than those ordinarily used, thus making possible a nearer approach to the conditions met in actual engineering practice. The concrete used was a 1:2½:5 mixture, the quantities being accurately measured in bottomless boxes. The theoretical proportions as determined by measurement of the voids were 0.82 cement, 2.375 sand and 5.0 stone. The cement used was Atlas Portland, 96 per cent. of which passed the No. 100 sieve. Neat briquettes developed an average tensile strength of 507 lb. per sq. in. at the end of 7 days. The sand was sharp and contained some fine material which it was thought would not detract from its quality. The broken stone was a blue limestone used in the concrete for a neighboring building. The fragments were sharp and angular and their greatest dimension varied from 1½ to 2½ in. The stone had been screened and contained no very small fragments. The sand and cement were thoroughly mixed, the thoroughly moistened stone was then added, and the entire mass was well worked before any water was added. Water was then poured slowly on as the shoveling proceeded, from 25 to 31 per cent. of water being usually added. This percentage is calculated as volume of water ÷ volume of concrete.

The wooden molds for the tension specimens were made in two solid parts held together by four bolts. The inside dimensions were such as would produce a specimen 39 in. long, 6x6 in. in cross-section, with circular heads 9 in. in diameter and 6 in. thick. The molds for the compression test pieces consisted of four pieces of seasoned wood so fitted as to form a specimen 15 in. long, with a 5x5-in. cross-section. The concrete for two specimens, one of each kind, was mixed in a single batch. In order to insure easy removal of the forms a thin coating of very soft soap was applied to the inner surface of the boards. This secured the desired result and also gave a smooth surface. The concrete was placed in the molds with a shovel and carefully tamped into place with a wooden stick. The forms were removed after two days, but the specimens were left on the base boards at least one week and during this time were frequently moistened. In both tension and compression tests the extensometer used was of the electric sounder type and had been carefully calibrated. In tension tests the original length over which the stretch was measured was 18 in., while in compression 12 in. was the interval in which deformation was measured.

The compression tests were made with a 100,000-lb. Riehlé machine. Two different styles of bearing surfaces were tried: paper cushions and those of plaster of paris. The former at once proved insufficient, but the latter distributed the pressure very evenly, especially when used in connection with thick, polished cast-iron plates, one placed between the upper surface and the descending head and the other on top of the adjustable bearing block at the bottom. A 150,000-lb. Emery testing machine was used for the tension tests. The circular heads of the specimen were inclosed in cases made by bending wrought-iron plate around their curved surfaces so as to fit over the largest possible area. These cases were securely clamped to the specimen and coupled to the heads of the machine.

Twenty-three compression and seventeen tension specimens were successfully tested. The age of the compression specimens when tested ranged from 112 to 146 days, the average being 131. In the tension pieces the range was from 125 to 167 days and the average 153. In conducting the compression tests the load was successively applied and removed and at each reapplication of load an increment varying from 500 to 3,000 lb. was added. Extensometer readings were taken at frequent intervals, while the column was under load and also each time the load was reduced to zero. The latter were taken to see if any set had taken place. The tension tests were conducted in a similar manner, but the increment of load added between readings was uniformly 500 lb.

While some of the compression tests show marked divergence from the general run the majority of them, especially those conducted under the best conditions, seem to indicate that the elastic limit of this concrete lies between 600 and 700 lb. per sq. in. This decision was reached through a study of a series of elastic deformation curves representing the relation between load in pounds per square inch and strain in inches per linear inch. The value of the elastic limit in tension could not be determined owing to the fact that the majority of the curves were practically straight lines. This can indicate either of two possibilities: the elastic limit may have been so near the breaking load that it was not noticed, or because of some fault, such as eccentric pull, the elastic limit may never have been reached. This, however, is a matter of mere conjecture.

The ultimate resistance developed in the twenty-three compression specimens averaged 904 lb. per sq. in. The lowness of this value can perhaps be attributed partly to the size of the stone and partly to the amount of water used in the concrete. Fragments of stone whose greatest dimension was in some cases 3 in. were perhaps too large for a 5x5-in. specimen. The fact that in nearly every instance the rock itself was crushed, even though it was a good quality of blue limestone, lends weight to this theory. As regards the amount of water used, it was noted that the driest concrete of all carried the heaviest load. Moreover, the broken section of this specimen showed homogeneous concrete, whereas the wetter concrete was more or less porous. In all the specimens the concrete was thoroughly rammed. The characteristic angle of shear of 45 deg. was in marked evidence in nearly all the tests. The breaking load of the tension specimens was correspondingly low. It was fairly regular and averaged for the seventeen specimens 100 lb. per sq. in. Here, too, the size of the stone and the quantity of water used were probably important factors. Another detail which affected the results somewhat was the fact that the specimens as molded were a little too large for the attachment casings and difficulty was experienced in trimming them evenly. In three cases at least the result was very evidently an eccentric pull which caused the specimen to break under a small load.

The coefficient of elasticity was determined by the formula, $E =$ stress in pounds per square inch of cross-section $\div$ deformation in inches per linear inch. The values were obtained by using in the equation the total deformation under the various loads, less the corresponding permanent deformations. This coefficient is frequently called the "true elastic coefficient." An average of eighty compression coefficients gave as the value of E, 2,764,000 lb. This compares very well with the value of 2,630,000 lb. derived from the mean of the curves before mentioned. The values of the coefficient in tension were more regular and the values derived graphically and by computation checked very closely. The average of seventy-four values of E was 2,670,000 lb., and the value derived from the mean curve was 2,700,000 lb. The conclusion drawn is that the coefficient of elasticity in concrete is the same for compression and tension.

The tests were conducted as thesis work in the Civil Engineering Department of Columbia University by Messrs. Henry L. Jochum and Samuel A. Schwarz, under the direction of Prof. Wm. H. Burr, head of the department.

Book Notes.

The fourth annual number of the "Jahrbuch für das Eisenhüttenwesen" shows an improvement in scope over preceding volumes, although the same good editorial methods are retained. It is in essence an index to the articles relating to the iron and steel industry which appeared during 1903 in 48 German journals and society publications and 93 issued in other countries. The more important articles of the year are reviewed at length and some of their illustrations are reproduced. The arrangement of the contents is such that all references on a subject are grouped together, while author and subject indexes enable a paper which is desired to be found quickly. (Düsseldorf, A. Bagel.)

The "Indicator Handbook," by Mr. Charles N. Pickworth, editor of the "Mechanical World," of Manchester, has recently appeared in a third edition. It is one of the best manuals on the subject and is marked particularly by its comprehensive nature. The first volume is devoted to the instrument and the manner of caring for it; its errors and those that arise from faulty attachment and reducing gear are explained in much detail. In the second volume the information to be obtained from the indicator diagram is discussed. The general features of accurate cards from engines in good condition are first explained and their relations to the action of the steam in the cylinder are pointed out. The effect of defective valve gear on the diagram is then taken up and afterward the cards from multi-expansion engines. The use of the indicator with internal combustion engines, compressors and pumps is fully explained, and useful tables are given. (New York, D. Van Nostrand Co., $1.50 per volume.)

A book on turbines and turbine installations by the chief engineer of Messrs. Escher, Wyss & Co., of Zurich, is certain to be a valuable contribution to this important subject, and it is therefore hardly necessary to more than glance at Mr. Viktor Gelpke's "Turbinen und Turbinenanlagen." It gives the essence of the author's studies with that company and also with Messrs. Th. Bell & Co., and Messrs. J. J. Rieter & Co. contributed drawings for some of the illustrations. When it is stated that the method of designing the blades, given in detail in the book, has been employed since 1900 by the Zurich company, the practical merit of the volume is apparent, for it is well known that some of the machines recently constructed by these builders approach closely the maximum possible efficiency. The book is in two parts, the first relating to the details of turbines. It begins with an explanation of the calculations relating to the water passages, blades and guides, which are made clear by numerous examples. Although graphical methods are given for some parts of this work, the practical application of the methods requires a great amount of tedious computation. The second chapter is on the pressure and velocity relations in turbines. After explaining the phenomena of the impact of water on a moving surface and the relations of the pressures within a turbine, the author deduces what he terms the main equation of pressure relations. The design of the general features of the turbine and draft tube is then taken up, completing the explanation of what, for lack of a better term, may be called the theory of the subject. In the next chapter the details of the various classes of turbines are worked out and a great mass of data is given which turbine designers will find of the highest value. It is particularly interesting to learn that the author's experience and study lead him to the belief that some types which have long been neglected can be improved so as to become very efficient machines, although he points out that some of the construction will prove quite difficult to detail satisfactorily. In the second part of the book Mr. Gelpke gives a description of the conduits, screens and gates used in hydraulic power developments and explains all the minor apparatus used about a power station. In addition to the praise the author deserves for this admirable treatise, the publishers merit commendation for the excellent form in which it has been issued. (Berlin, Julius Springer; 15 marks.)

The "Handbook of Mathematics" is a book which Mr. Otis Allen Kenyon states is mainly a translation of Claudel's "Introduction a la Science de l'Ingenieur," but those acquainted with that pocketbook will hardly recognize the French original in its translated form. It is a large octavo of over 700 pages printed in good, clear type on opaque paper and has none of the appearance of an ordinary handbook. Whether the translator or publisher is responsible for this departure from precedent matters little: the fact that somebody has at last produced a reference manual for engineers in some other shape than the "pocketbook" form deserves special and long-continued applause. These books are not carried about on the person of the engineer except in a very few cases, which are not at all important, but they are used in offices, often poorly lighted, where legible print means a good deal to the reader. This book is essentially an office reference book. It gives the principles of arithmetic, algebra, geometry, trigonometry, analytic geometry and the calculus in such form that a single volume replaces pretty well separate books on each of these branches. As the translator points out, the office use of mathematical text-books for reference is discouraging. If a busy man wishes to solve an integral which is not given in the tables, he spends several hours studying the text-book, only to find that his difficulty lies farther back in trigonometry or algebra. As a result he throws up the whole thing and says he has forgotten his calculus. With this handbook, in which cross-references make the connections between different branches very easy to trace, difficulties of the sort mentioned are reduced to a minimum. (New York, McGraw Publishing Co., $3.50.)

Under the title of "The Crisis at Panama" Mr. Lindon W. Bates has published a series of nine papers discussing in very pointed language the 85-ft. canal project for crossing the Isthmus. In the preface he gives figures to prove that the work already done and the payments already made for that work indicate that it is wholly impracticable to carry out the 85-ft. project without an expenditure far beyond the sum authorized by Congress; the uncertainty concerning the practicability of the plan, coupled with this prospect of enormous expenditures, to complete it, even if it is practicable, is the author's excuse for again attacking in detail the main features of the project. Taking advantage of the example set by the official advocates of the 85-ft. level canal, who deluged the newspapers at one time with statements of the inability of the majority of the Board of Consulting Engineers to reach a sound conclusion on a subject the same officials had selected them to review, Mr. Bates makes some comments on the qualifications of the minority of the same Board to give opinions concerning such a canal, and gives quotations from former statements by some of them which are hardly in keeping with the 85-ft. level argument. The difficulties of executing the work as respects labor and sanitation and the terms of the proposed contract are next reviewed, and the form of contract is termed a "speculation for plungers," mainly on account of the fact that it is to be signed before plans are prepared for any of the important works and the whole business aspect of the agreement is to be determined, after the contract is executed, by a committee in which the contractor has only a minority representation. The author then takes up in detail the proposed locks at Gatun, the Mindi location, the Gatun dam and lock site, the line from Culebra to Panama, and the cost of the Pacific section. The book is a decidedly interesting one, and the excellent illustrations accompanying it give a very good idea of the topography of the Canal Zone. The book is published by the author, at 111 Broadway, New York.

Readers of this journal will doubtless recall the occasional appearance in its pages of articles by Mr. Ernest McCullough on subjects connected with municipal engineering and surveying. For a good many years he has been engaged in such work or in business bringing him into close touch with municipal engineering and construction, and in a book on "Engineering Work in Towns and Small Cities," which he has recently written, he gives the information on the subject which his experience and observation indicate to be of use to commissioners, engineers and contractors in such places. The subjects covered are roads and streets, sidewalks, curbs and gutters, pavements, street cleaning, garbage disposal, drainage, sewerage, water supply, concrete, building regulations, contracts and specifications, office systems, city engineering records, field work and a large mass of engineering data of use in designing city works. The author very frankly claims little originality for his book, but states that there is hardly anything recommended in it which he has not tried personally and found to be useful. The result is a manual which members of city councils or boards of public works who have to pass upon engineering subjects will find decidedly valuable. The author's decision to restrict the field covered to the works of small communities has enabled him to avoid the mass of detail involved in public works of large cities, and on account of this omission of advanced technicalities, it has been possible to answer in this volume most of the questions likely to arise in small undertakings. The book is also fitted for the use of engineers who take up municipal work for the first time, not only on account of its abundant information concerning engineering subjects, but also for its useful suggestions on the organization of city engineering offices and systems of records. Taking the book as a whole, the author has accomplished a rather difficult task in a decidedly creditable manner and the volume deserves a wide circulation. (Chicago, Technical Book Agency; $3 in cloth, $4 in leather.)

Mr. W. C. Copperthwaite, engineer of bridges to the London County Council, has written a book on "Tunnel Shields and the Use of Compressed Air in Subaqueous Works" which furnishes information not available for ready use in any other book in English, in fact a considerable part of the data is new with the book. The author was connected with some of the London tunneling operations and is personally acquainted with many of the engineers who have taken part in the development of shield tunneling, so that his sources of information are unusually good. The latest great advance in such work, recently perfected in this country by Mr. Jacobs to enable tunnels to be driven in some soils without the removal of any spoil whatever, is not mentioned in the book, but in other respects it covers the subject very thoroughly. The first chapter gives the history of the shield from Brunel's patent in 1818 down to the inventions of Greathead, and the second chapter is a similar historical sketch of the use of compressed air in foundation and tunneling operations, with notes on the effect of compressed air on men working in it. The use of cast-iron linings for tunnels is then explained and illustrations of the linings of a number of tunnels are given. The fourth chapter is an interesting account of the work done by the Greathead shield in London clay, where this means of tunneling has had its greatest use. The next three chapters are on the use of the shield in water-bearing material and give not only general information about important works of this nature, but also a number of practical notes which have never before been published. The eighth and ninth chapters are on the shield in masonry tunneling and explain the design and construction of roof shields, like that employed in Boston and a number of European cities. A number of tunneling operations recently carried out with the shield or by the use of compressed air are described in the tenth chapter, and in that following there is given an estimate of the cost of such work. There are two appendixes giving a chronological list of events connected with shield and compressed air tunneling, and a list of British patents on such work. The book is profusely illustrated and is written in a business-like style that makes it most welcome to a busy engineer. (New York, D. Van Nostrand Co., large 8vo, $9.)

The second volume of Mr. Frank W. Skinner's "Types and Details of Bridge Construction" is a description of many railway and highway plate-girder spans and a discussion by eminent specialists of various features of design. The author has brought together from many sources a large amount of information concerning good, indifferent and bad girders, which shows the development of this class of structures by competent engineers and the freaks built by others. It is pointed out that the examples are not necessarily models, but as their adoption in some cases was due to circumstances of which nothing is now known, criticism is generally avoided, and the reader is guided along the path of good practice by the special chapters on design. The first part of the book is devoted to the general features of American plate girders and the calculations employed in designing them, specifications, construction and erection, and drafting office rules for girder work. In the second part descriptions are given of railroad plate girder spans, arranged in chapters according to the length of span, so that anybody looking for information concerning spans of 80 to 100 ft., for example, can turn directly to the portion of the book devoted to them. In the third part a great number of details of such spans are illustrated, which show in an interesting manner the different solutions for the same problems which have been adopted by various engineers and bridge shops. In the fourth part the information relates to viaducts, bridge approaches and elevated railways, and in the fifth part highway and special spans are described. The last part will be found of special value by most readers, for it gives explanations of what may be called the best current practice. An explanation of the computations required in the design of plate girders has been contributed by Prof. H. S. Jacoby, Dr. J. A. L. Waddell furnishes notes on general design. Mr. H. W. Hodge discusses the fundamental considerations in plate girder practice, Mr. J. V. W. Reynders has an article on the essentials of plate-girder spans, Mr. John Sterling Deans describes some features of plate-girder construction, and Mr. J. B. French discusses plate-girder construction for railroad bridges. (New York, McGraw Publishing Co., $4.)

A monograph on massive concrete has been prepared by Prof. N. A. Shitkewitsch, of the Royal Engineering School at St. Petersburg, in which the subject is discussed from the viewpoint of monolithic work. The book is entitled "Monolität der Beton-Bauten" and is based very largely on experimental data obtained by other investigators and on the author's observations of the behavior of concrete in civil and military works. A specially interesting feature is a group of illustrations showing the effect of gun-fire on concrete. The various aspects of the subject are discussed in the following order: The influence of moisture on changes of volume of the ingredients of concrete, the influence of the temperature of the air on mortar and concrete, the effect of the phenomena of hardening on the permanency of volume of concrete, the mechanical properties of concrete, the influence of the method of conducting the work on the monolithic properties of the concrete, the influence of the structural design on monolithic properties, methods of construction which tend to produce monolithic masses, and the effect of dampness and frost on concrete. It is evident from this outline of the contents that under "monolität" the author refers to freedom from through-going cranks; his conclusions on the subject read as follows: "1. The smallest changes in volume are shown by lean, porous concrete prepared from good cement and limestone, granite and brickbat aggregates. 2. In order to secure the greatest uniformity in the concrete and avoid the appearance of horizontal cracks it is necessary to place the concrete continuously and to loosen up the top surface of the successive layers. 3. The limiting dimensions of the masses of concrete depend in each case on the properties of the concrete, the influence of moisture, the temperature and the design; the maximum dimensions are reached when the conditions of the design have the least influence on the changes of form which the mass is free to show. 4. It is necessary to give the maximum possible independence to concrete exposed to different loads and atmospheric conditions, which is accomplished by dividing the entire work into separate monoliths by vertical and horizontal joints. 5. To protect exposed surfaces of concrete against the destructive influences of the weather it is necessary (a) to give the outside surfaces a strong coating of some sort and (b) to water-proof all other exposed surfaces. Although some of the author's conclusions seem to rest on data too incomplete to be of much value, the book as a whole brings together a large amount of information on a subject that has received comparatively little attention although of much importance.

Letters to the Editor.

Timber Structures.

Sir:—I was glad to see your article of Nov. 24 on timber tests because it indicates that your journal is alive to the importance of timber in engineering work. Up in this part of the world we use a great deal of timber in engineering work and most of us are agreed that we use it wastefully. It is hard to break away from old habits, however, particularly when to break away means spending a lot of time for which there are other demands that are more pressing. Nevertheless it is unfortunate that engineering has so long been content to treat timber as a carpenter's material and not worthy to be classed with steel and concrete. It is really one of the most important materials of engineering and why it remains neglected in the face of its rapidly rising price is something hard to explain. The only explanation of its neglect that I ever heard was that it was worked too easily for an engineer to consider it deserving of attention, a statement that manifestly is an attempted joke on the secret rites with which some engineers are accustomed to veil their simplest operations.

It is only necessary to consider the item of timber trestles to learn how much improvement can be made by learning more about the properties of timber and then applying that knowledge. Every railway company has its standard plans for such structures, probably drawn up years ago when timber was plentiful. At that time the main thing was to design a structure which was strong enough, not one where the timber was employed most economically. As a result most of the standard plans for the smaller roads show details bound to result in local deterioration long before the main part of the trestle is worn out. On paper the design is doubtless correct, but the experienced superintendent of bridges will be able to detect details which hasten rot in their vicinity. In talking with engineers of other roads using timber trestles I have found the same experience to apply with them, and it accordingly seems to me that a careful investigation ought to be made of the design of trestles, for the purpose of ascertaining details which will result, so far as possible, in a more uniform deterioration. Of course this investigation should be accompanied by an examination of the properties of the class of timber we can now get for trestles, which is considerably different from that of fifteen years or so ago.

These structures must also receive more attention from the maintenance standpoint. Most of them are left to the judgment of bridge foremen, who determine when it is time to make minor repairs. Nominally the foremen report to the superintendent of bridges, who is supposed to pass on the repairs before they are made. Practically the foreman is left in charge, with orders not to spend more than a certain sum, all told, in a given period. Most of these men are competent and conscientious workmen, but very few of them have the technical knowledge really necessary to insure the most economical use of the large sums of money spent annually on timber repairs. I do not believe that it is practicable to lay down general rules for such work, because the cost of repairs differs so much with different trestles, even if they are of approximately the same dimensions and type. For example the location of a trestle may make ten or fifteen per cent. difference in the cost of labor on it, to say nothing of the difference in cost of supplies delivered on the site. Then again the location of the trestle may make it desirable to use special grades of timber for certain parts of it, as for piles in marshes in the South, or for trestles likely to be filled in within a few years. For this reason I believe that there should be a reform in the system of maintenance of such structures, by which the cost of each of them is recorded in detail together with the cost of repairs and notes concerning such features of the trestle and its surroundings as will enable the engineer really to know whether it is time for it to be rebuilt or whether more repairs should be made. It is of course possible to keep on repairing trestles until nothing of the original material is left in them, but as repairs are more expensive than rebuilding there is manifestly a point where they should stop and the structure be replaced by a new one.

Engineers connected with the wealthy trunk lines tell me that word is reaching them from time to time from the high executive officials that they must pay more attention to the financial aspects of their work, to design structures so that the interest on their first cost plus maintenance charges shall be the minimum possible with the kind of business done. Those of us who are employed on the small lines get the same suggestions directly from the executive officers every time they go over the roads. It is good advice because we are all inclined at times to recommend designs or repairs which gratify our technical senses, although we know that they are really not absolutely necessary. We sin most in timber work, probably, not only because an engineer dislikes to see any defect in timber but also because the bridge foremen and inspectors are continually egging us on to do things that sober consideration from the combined standpoint of business management and engineering practice would show to be unjustifiable. If we had the same good knowledge of timber that we have of steel and masonry we would be much better off, and I am glad to see that your journal has called attention editorially to the fact.

Yours truly, Resident Engineer.

Grand Rapids, Dec. 1.

Tests of Longitudinal Shear in Timber.

Sir: I value highly your kind notice of the timber tests now being conducted by the Forest Service, U. S. Department of Agriculture, in the issue of Nov. 24. Referring to your comment on the value of information concerning the liability of failure of stringers due to longitudinal shear. I wish to say that this matter has been under investigation since the tests first began. It was apparent to us in our early experience with full-size beams that failures under longitudinal shear were important and frequent. The data now on hand serve to establish reliable values of the shearing stresses which it is not safe to exceed in full-size stringers. Circular No. 32, published August, 1904, presented a table of these shearing stresses, reproduced herewith.

Ultimate Shearing Strength, Rings per Inch, Percentage of Moisture of Timber.

Species.	Size.	Grade.	Rings.	Moisture.	Shear.
Red fir	1.5x3-in.	All:			
104 tests		Average	17.9	19.8	702
		Maximum	34.0	22.1	1,136
		Minimum	5.0	17.1	296
Red fir	"	All:			
108 tests		Average	11.1	..	720
		Maximum	27.0	..	1.025
		Minimum	30.0	..	286
West'n hemlock	"	All:			
120 tests		Average	9.9	33.4	764
		Maximum	23.0	53.9	1,058
		Minimum	5.0	20.2	496
Loblolly pine	"	Square edge:			
77 tests		Average	3.6	83.0	657
		Maximum	11.0	180.0	1,047
		Minimum	2.0	36.0	342
Loblolly pine	"	Square edge:			
26 dry and		Kiln dried—			
27 soaked		Average	5.1	0.7	480
tests		Maximum	8.5	5.7	779
		Minimum	2.0	0	251
		Soaked—			
		Average	4.6	73.6	607
		Maximum	1.0	180.3	941
		Minimum	2.0	40.3	276
Longleaf pine	"	Merchantable:			
38 tests		Average	21.6	21.4	992
		Maximum	39.0	39.4	1,257
		Minimum	8.0	18.5	800

Resistance to Splitting Due to Longitudinal Shear under Cross Bending.

		Sticks fail'g	Shear, lb. per sq. in.			Sticks not failing	Shear, lb. per sq. in.		
Species.	Dimensions.	Number.	Average.	Maximum	Minimum.	Number.	Average.	Maximum.	Minimum.
Red fir	8x16-in.x16-ft.	8	297	345	228	24	170	413	79
Red fir	6x 8-in.x16-ft.	5	343	517	146	24	170	413	79
Red fir	8x16-in.x16-ft.	7	223	273	173	11	201	318	117
Red fir	8x16-in.x16-ft.	7	247	395	74	22	171	390	96
Red fir	6x 8-in.x16-ft.	7	247	395	74	22	171	390	96
Longleaf pine	10x12-in.x16-ft.	3	268	291	247	19	243	330	151

The results of the tests to determine the actual shearing strength of the wood will be found in the accompanying table. These tests were made on small test pieces, a projecting bead on each of which was sheared off. The test piece was so designed as to yield a failure in true shear without an accompanying failure in compression or bending.

When a beam becomes weakened by windshakes or season checks it is apt to fail under longitudinal shear. That is to say, it splits from the end of the beam toward the center, instead of failing in tension or compression at the center of the span. The liability to failure under longitudinal shear decides the strength of a beam of short span. The table indicates the strength of the various sticks in longitudinal shear. The strength is given in pounds per square inch of horizontal section of beam. The strength of the area of wood actually sheared off is greater than these values. The latter include the effect of openings in the wood between the fibers due to checks, etc. The values are those that should be used in designing beams to carry loads.

A publication entitled "Second Progress Report on the Strength of Structural Timber" is now in press, and will present among other things the full range of values of horizontal shear developed in full-size beams. In this report occurs also the results of an extended series of tests to determine the reducing factors of knots of various kinds and various locations.

Very truly yours, W. K. Hatt.

Lafayette, Nov. 27.

The Depreciation of Contractors' Plant.

Sir:—A short time ago I was called upon to act as an arbitrator between a contractor and a railway company concerning some accounts that were in dispute. A large piece of construction had been placed under contract on a percentage basis, but was stopped before more than half of it was finished. Under the terms of the contract it was possible to determine without difficulty most of the various items for the final settlement, but there were a few, of minor importance, which could not be settled on the basis of contract terms. One of these related to the proper charges to be made for plant used on the work, and I must confess that, as a lawyer the appraisal of this item was something entirely foreign to my previous experience. It was essential to reach some fair conclusion, however, and accordingly I sent out letters to a number of contractors doing similar work asking them for estimates of the life of their plant when used with fairly competent men. There was a range of over one hundred per cent. in these estimates. I then tried to secure from dealers in second-hand equipment information as to the prices they paid for different kinds of plant, but met with still greater variations in estimates. Finally I averaged all the figures obtained and made the award on the following basis: Nothing was allowed for picks and shovels, drag and wheeled scrapers were estimated to have an average depreciation of 33⅓ per cent. annually, carts 30 per cent., steam shovels 20 per cent., narrow-gauge rolling stock 20 per cent., and air compressors 15 per cent. Both parties seemed to be satisfied when these figures were used in reaching the total cost of the work done, but the chief engineer of the railway company suggested that I send you this statement of my results as a matter of possible interest to your readers. I do not think that they are of much value, because the cost of maintaining the equipment in this case was a matter of record on the payrolls and supply accounts, while the estimates I received from other contractors and dealers in second-hand equipment probably included both maintenance and depreciation charges. I was much struck by the frank statement of the railway's engineers that they did not know very much about the actual charges which should be made for plant used by the contractor. On most portions of this contract the main items of expense were for labor and supplies, which anybody could estimate closely, but on some heavy rock cuts the mechanical expenses were manifestly very high. It occurs to me that a discussion of these expenses would be a profitable subject for your readers.

Yours sincerely, **Attorney.**

New York, Nov. 30.